THE
ELEMENTS
OF
MATERIA MEDICA
AND
THERAPEUTICS.

BY

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> "Si quid novisti rectius istis,
> Candidus imperti; si non, his utere mecum."

FINSBURY SQUARE,
December 1848.

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ELEMENTS

OF

MATERIA MEDICA

PROLEGOMENA.

(*Definitions.*)

Therapeutics (*therapeia*, *therapeutice*, *therapeutica*, from θεραπεύω, *I cure*) is that branch of medicine which has for its object the treatment of diseases. It is divided into *general* (*therapeia generalis*) and *special* (*therapeia specialis*).

Authors are not agreed as to the proper limits of Therapeutics. In the most extended sense of the word, and which I have adopted in the text, it embraces all the known means of cure, and consequently all surgical operations. Guersent[1], however, excludes Amputations, Lithotomy, Tracheotomy, &c. from its domains, though he includes Bloodletting, Issues, Setons, Acupuncture, and all those operations which are useful in the treatment of diseases, by producing modifications of the vital properties.

Sprengel[2] applies the term *Iatreusologia* (from ἰατρεύω, *I cure*, and λόγος, *a discourse*) to general therapeutics.

Acology (*acologia*, from ἄκος, *a remedy*, and λόγος), or *iamatologia*[3] (from ἴαμα, *a remedy*, and λόγος), is that department of therapeutics devoted to the consideration of remedies.

Some authors[4] limit Acology to the consideration of surgical and mechanical remedies.

The term **Materia Medica** implies material substances employed in the treatment of disease; but, in a more extended sense, it signifies all remedial agents, of whatever kind. It is also used to designate that department of medicine devoted to the consideration of remedies or medicines.

Remedies (*remedia*, from *re*, and *medeor*, I heal; *auxilia medica*) are agents used in palliating or curing diseases.

They are of two kinds: those which operate through the agency of the mind; and those which act on the body directly[5].

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[1] *Dictionnaire de Médecine*, t. xx. art. *Thérapeutique*: 1828.

[2] *Institutiones Medicæ*, t. i. p. 7.

[3] C. H. E. Bischoff, *Die Lehre von den chemischen Heilmitteln*, Bd. i. S. 22: Bonn, 1825.

[4] Sprengel, and C. H. E. Bischoff, *op. supra cit.*

[5] Strictly speaking, this division is, perhaps, inaccurate; since we know that changes in the condition of the brain produce corresponding alterations in the state of the mind; and it may be fairly inferred, that changes in the state of the mental faculties are necessarily associated with some mo-

The first may be denominated *psychical* or *mental* remedies; the second, *somatical* or *corporal*. The latter are subdivisible into *imponderable*, *hygienic*, *mechanical* or *surgical*, and *pharmacological* agents.

PART I.—PSYCHICAL OR MENTAL REMEDIES.

(*Remedia psychica*).

Affections of the mind, by their influence over the corporal functions[1], favour or oppose the action of morbific causes, and modify the progress of diseases. The methodical application of them as remedies constitutes the *psychical method of cure*.[2] Regarded as therapeutical agents, they are by no means unimportant, or to be neglected; though their employment is necessarily limited, on account of the difficulty experienced in producing, regulating, and controlling them.

They are of two kinds, *external* and *internal*[3].

1. EXTERNAL AFFECTIONS OF THE MIND.

(*Sensations*).

Those mental affections which immediately result from the influence of agencies external to the mind, are denominated *sensations* or *external mental affections*. They arise either from influences external to the body (*external sensations*), or from organic causes existing within the body (*internal sensations*).

External sensations are frequently excited for therapeutical purposes. Their influence over disease is either direct or indirect. It is *direct* when the effect is the immediate result of impressions made on the sensitive nerves. In this case sensations usually act either as excitants or as soothing and tranquillizing agents. Thus, strong light and loud noises are excitants; while monotonous impressions on the auditory or optic nerves dispose to sleep. The influence is *indirect* when the effect arises from internal mental affections suggested by the sensations. Thus the remedial influence of music is indirect, because it is referable not to the mere perception of sounds, but to the resulting emotions. In such cases, the effect being due to associated ideas or suggested feelings, is not uniform.

1. SMELL.—Those substances which are employed in medicine on account of their odour, are denominated Odoraments (*Odoramenta*). They are used for various purposes, of which the following are examples:—

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lecular alteration in the cerebral substance. If this be true, all remedies are somatical or corporal. But at present it is convenient to speak of *mental* as distinguished from *corporal* agents, just as we speak of *functional* as distinguished from *organic* diseases.

[1] For some pertinent observations on the powerful influence of mental impressions in deranging the functions of the body, see Dr. J. Johnson's *Essay on Indigestion*, 10th edit. 1840.

[2] J. C. Reil, *Rhapsodieen über die Anwendung der psychischen Kurmethode auf Geisteszerrüttungen*, 2d Ausg., Halle, 1818. Also, E. F. von Feuchtersleben, *Lehrbuch der ärztlichen Seelenkunde*, Wien, 1845.

[3] On this subject consult Dr. Thomas Brown's *Lectures on the Philosophy of the Human Mind*, vol. i. p. 341, 2d edit. 1824.

α. Strongly odorous vapours (as of ammonia and acetic acid) are used, both as preventives and remedies, for fainting, and attacks of hysteria and epilepsy.

β. Fragrant substances are employed both for the agreeable sensations they excite, and for the purpose of overpowering or disguising disagreeable odours. The *pot-pourri* or scent-jar, the *sachet* or scent- or sweet-bag, the sweet coffer, perfumed oils, spirits, and waters, scented soaps, fumigating pastils, &c. are used for these purposes. Perfumes are to be distinguished from substances called disinfectants; the former disguise, while the latter destroy, noxious vapours, &c.

Odorous emanations from young and vigorous animals have been esteemed salutary[1]; and to them have been sometimes, though erroneously, ascribed the beneficial effects supposed to arise from a residence in stables[2]; as well as from the ancient practice[3] of putting young, vigorous, and healthy subjects to bed with the old and enfeebled[4].

In considering the therapeutical influence of odours, the singular sensitiveness of some constitutions (the hysterical chiefly) to perfumes should not be forgotten. The inhabitants of Rome, especially the females, are remarkable for this peculiarity. In them, headache and numerous other nervous affections are readily produced by the agreeable odours of flowers and other perfumes[5].

2. TASTE.—Sapid substances are frequently employed in medicine for affecting the sense of taste, as in the following instances:—

α. Pungent and acrid substances (as horseradish and ginger) are employed to excite the gustatory nerve in ageustia, or loss of taste.

β. Bitters, and the substances called *condiments*, heighten the appetite for food, for which we frequently use them in medicine. They probably act, in part at least, by their action on the nerve of taste.

γ. An important object in the art of prescribing is to disguise the unpleasant taste and smell of medicines by substances possessing a more agreeable flavour and odour[6]. The employment of gelatinous and membranous capsules to envelope medicines, has for its principal object the avoidance of the unpleasant taste of the substances swallowed.

δ. In some nervous cases, we endeavour to increase the faith of our patients in the powerful agency of the remedies employed, by augmenting the odorous and sapid qualities of the substances used.

3. HEARING.—Impressions made on this sense are useful as remedial agents, either by their direct effects, or indirectly by the internal affections of the mind which they give rise to.

α. Noises act as direct mental stimulants. They check sleep, and are sometimes useful by diverting the attention[7].

β. Monotonous sounds (as the humming of bees, the ticking of a clock, the murmur of a rivulet, a dull discourse, &c.) soothe and dispose to sleep. In therapeutics we avail ourselves of this fact, and combat want of sleep by directing an attendant to read aloud and monotonously to our patient.

γ. Silence disposes to sleep. In cases of vascular or nervous excitement of the brain, in fevers, and in many other cases where sleep is desired, silence should be enjoined. Under some circumstances, however, silence "may become a stimulus when sound ceases to be so. Thus, a miller being very ill, his mill was stopped, that he might not be disturbed with its noise; but this, so far from inducing sleep, prevented it altogether; and it did not take place till the mill was set a-going again[1]."

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[1] H. Cloquet, *Osphrésiologie; ou Traité des Odeurs, du Sens et des Organes de l'Olfaction*: Paris, 1821.

[2] Beddoes, *Observations on the Medical and Domestic Management of the Consumptive*, &c., Lond. 1801.

[3] 1 *Kings*, chap. i. v. 1—4.

[4] *Anecdota Sydenhamiana*, p. 62, Lond. 1845. Copland, *Dict. of Pract. Medicine*, vol. i. p. 475, and vol. iii. p. 135.

[5] Sir James Clark, *The Sanative Influence of Climate*, p. 230, 3d edit., Lond. 1841. Orfila, in his *Traité de Toxicologie*, vol. ii. p. 543, Paris, 1843, has collected several cases of supposed poisoning by the emanations of odoriferous plants. In the case of Casper Hauser (see Copland's *Dict.* vol. i. p. 474), the most remarkable and singular effects were produced by odours.

[6] For illustrative examples, see Paris's *Pharmacologia*, p. 443, 9th edit. 1843.

[7] "Quorundam discutiendæ tristes cogitationes; ad quod symphoniæ, et cymbala, strepitusque proficiunt" (Celsus, lib. iii. c. 18).

δ. Harmonious and melodious sounds influence the mind chiefly in an indirect manner, and excite a sensation of either pleasure or pain, according to the nature of the ideas they are associated with, or the feelings which they suggest (see *Music*).

4. VISION.—On this sense, as on hearing, remedial impressions act either directly or indirectly.

α. Strong light operates as a mental excitant, and checks sleep. In bright solar light we feel more active, cheerful, and happy; whereas obscurity and darkness give rise to a gloomy and depressed condition of mind: hence, insolation in the open air is employed as a mental stimulus in melancholy, lowness of spirits, and despondency.

β. Different coloured lights exercise different effects on the mind. Thus, certain tints are popularly called cheerful or lively, while others are termed sombre. Hence, in the treatment of insanity, the colour both of the patient's chamber, and of the works of art which surround it, is not undeserving of attention. Feuchtersleben suggests the use, in these cases, of coloured glass for windows and spectacles.

γ. Sleep is promoted by "the sight of any thing waving; as of a field of standing corn, or of the hand drawn up and down before the face by a mesmeriser, attracting attention much more than an object at rest[2]."

δ. Darkness, especially when accompanied with silence, has a calming and depressing influence, and disposes to sleep. Hence it is employed in cases of great vascular or mental excitement of the brain, and where we desire to produce sleep. In some instances it excites great terror.

ε. Fixing the eyes steadily on a single object, as a candle, or a hole in the wall, will sometimes induce sleep.

5. TOUCH.—Of the therapeutical uses made of this sense, the following are a few illustrations:—

α. Gentle friction[3] with the fingers on some part of the body disposes to sleep. Its soothing and lulling effects I have repeatedly experienced when suffering from severe headache. "I know a lady," says Dr. Elliotson[4], "who often remains awake, in spite of every thing, till her husband very gently rubs her foot."

β. "A combination is still more effective: whence, experience has taught nurses to rock, and otherwise agitate infants, while they hum them to sleep[5]."

γ. Freedom from pain and uneasiness of any kind favours sleep.

δ. In some soporose affections, as poisoning by opium, apoplexy, &c. remedies are resorted to which, by exciting the sensibility of the body, are calculated to rouse the patient, and prevent sleep. Various methods of causing pain have been devised: one of the oldest is *urtication*, or flagellation by a bunch of nettles (*Urtica dioica*). This practice is mentioned by Celsus[6].

ε. Pectination, or combing the hair, disposes to sleep, and is often resorted to for this purpose.

ζ. Brushing is used to allay cutaneous irritation, and occasionally to provoke sleep.

η. Rubbing, and various other kinds of manipulation, are employed as soothing means. Dry rubbing is very serviceable in œdema of the limbs.

θ. Titillation has been suggested and used by Mr. Wardrop[7] as a remedy for paralysis (of sensation?). The mode adopted was to pass a feather lightly across the palm of the hand, three or four times daily, until laughter was occasioned.

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[1] Dr. Robert Macnish's *Philosophy of Sleep*, p. 32: Glasg. 1830.

[2] Dr. Elliotson's *Human Physiology*, p. 608, 5th edit. 1840.

[3] The friction above referred to should be very light and gentle. Strong or violent friction by the hand or horse-hair gloves is used for other purposes; as, for allaying itching and irritation of skin, and promoting cutaneous circulation. Dinneford's "*Patent improved Electrical Horse-hair Renovators*" are, for these purposes, a great improvement over the ordinary horse-hair gloves.—On the subject of friction as a remedial agent, the student may consult Celsus, lib. ii. c. 14.

[4] *Op. cit.* p. 609.

[5] *Ibid.*

[6] Lib. iii. c. 2.

[7] *Edinb. Med. and Surg. Journ.* vol. viii. p. 197.

Monotony.—It has been already stated that monotonous impressions on the organs of hearing, seeing, or feeling, are great provocatives of sleep. This is the principle of the "method of procuring sound and refreshing slumber at will" recommended by the late Mr. Gardner, who called himself the *hypnologist.* His method was for some time kept secret, and was first made public by Dr. Binns[1]. It is as follows:—

Let the patient "turn on his right side, place his head comfortably on the pillow, so that it exactly occupies the angle a line drawn from the head to the shoulder would form, and then, slightly closing his lips, take rather a full inspiration, breathing as much as he possibly can through the nostrils. This, however, is not absolutely necessary, as some persons breathe always through their mouths during sleep, and rest as sound as those who do not. Having taken a full inspiration, the lungs are then to be left to their own action; that is, the respiration is neither to be accelerated nor retarded too much; but a very full inspiration must be taken. The attention must now be fixed upon the action in which the patient is engaged. He must depict to himself that he sees the breath passing from his nostrils in a continuous stream, and the very instant he brings his mind to conceive this apart from all other ideas," he sleeps. "The instant the mind is brought to the contemplation of a single sensation, that instant the sensorium abdicates the throne, and the hypnotic faculty steeps it in oblivion."

2. INTERNAL AFFECTIONS OF THE MIND.

This division of mental affections includes the *feelings* and the *intellect.*

1. THE FEELINGS.

Under the denomination of *feelings* or *affective faculties* are included what the phrenologists denominate the *propensities* and *sentiments.*

The therapeutical regulation of the feelings or passions is principally resorted to in nervous and mental disorders; and consists in the repression or encouragement of particular feelings according to the circumstances of each case. "One insane," observes Dr. Spurzheim[2], "will behave well by veneration; another by fear; a third will be guided by love of approbation, often by attention paid to his self-esteem; many, by gentle manners and kindness; melancholic, anxious, and fearful patients, by the greatest mildness." The same author further observes, "every object which may excite the deranged feelings must be removed. This is the case with religious insanity, in pride, in melancholy, and in any other feeling. How injudicious is it, therefore, to give books to persons insane from religion, or to let them hear sermons, which nourish their disorders; or to keep with melancholics a conversation on the subject of their despondency."

Hope is a mildly stimulating or tonic passion, which may be beneficially employed in most cases, and which proves injurious in few, if any. Most patients receive, with satisfaction and benefit, assurances from their medical attendant of the prospect of recovery. Even in diseases of a mortal character, life may be sometimes prolonged by concealing from the sufferer the fatal nature of his malady[3].

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[1] *The Anatomy of Sleep; or the Art of procuring sound and refreshing Slumber at Will*, p. 436, 2d. edit. 1845.

[2] *Observations on the Deranged Manifestations of the Mind, or Insanity*, Lond. 1817.

[3] For some judicious remarks, by Sir H. Halford, on the duty of the physician, in withholding from, or communicating to a patient, the probable issue of a disease displaying mortal symptoms, see *London Medical Gazette*, vol. vii. p. 602. I fully agree with the late learned President of the College of Physicians, that the first duty of the physician is, "to protract the life of his patient by all practicable means."

Faith in the beneficial agency of the remedies employed, and *confidence* in the skill of the medical attendant, are important adjuvants in the treatment of most diseases. To them both physician and empiric owe part of their success; and it is, therefore, the duty of the practitioner to encourage these feelings in his patient by every legitimate and honourable means.

The influence of the *imagination* on disease has long been known, and is a fruitful source of fallacy in therapeutics. Extraordinary cures have frequently been ascribed to inert and useless means, when, in fact, they were referable to the influence of the imagination[1].

Fear is a depressing and debilitating passion, of whose power over disease the practitioner has sometimes availed himself. Thus Boerhaave prevented the recurrence of epileptic attacks (brought on by a person falling down in a fit in the sight of the hospital patients), by directing a red-hot iron to be applied to the person who should next be affected[2].

Removal from home, or separation of the insane from their families and society, is an important agent in the treatment of lunatics, and the influence of which is referable chiefly to the feelings and passions. It is calculated to act beneficially, by withdrawing the patient from the influence of domestic circumstances calculated to add to, or at least to keep up, the morbid condition, and by presenting new objects to his view, which arrest his attention, and excite new trains of ideas[3]. "Persons insane by pride," observes Dr. Spurzheim, "are seldom cured in the bosom of their family, where they are accustomed to command." In this case removal is desirable; so also, in madness from misanthropy, jealousy, hatred, or malice, removal is absolutely necessary. There are cases, however, where separation is objectionable; as where the intellect is not much disordered, and the attachment of the patient to his relatives is very strong.

There can be no doubt that the injurious effects of *coercion* or *restraint*, formerly considered essential to the successful treatment of insanity, are chiefly referable to the injured feelings[4].

The state of the *sexual feelings* frequently demands the attention of the physician. Marriage is sometimes recommended to remove the temptation to solitary vice; and, in epileptic and hypochondriacal cases, I have witnessed its beneficial effects. There are cases, however, where it may prove injurious, as in diseases of the heart.

2. THE INTELLECT.

Under this head are included both the *perceptive* and *reflective faculties*, which, as well as the feelings, may be frequently and advantageously influenced for therapeutical purposes.

The influence of *music* is referable to this head. It has been employed in the treatment of diseases (especially those of the mind) from very remote times[5]. The most ancient notice of its remedial use occurs in the Bible[6], where the sacred historian tells us that David cured the melancholy of Saul by it. This happened more than a thousand years before Christ. The ancient Greeks also had recourse to music in medicine, though Hippocrates makes no mention of it. It would appear to be principally adapted for the elief of the melancholic form of insanity, but its beneficial effects are very transitory, and ave been greatly exaggerated. Esquirol[7] tried it at Charenton in every way, and under the most favourable circumstances, but with little success. "Sometimes," he reports, "it rendered the patients furious, often it appeared to divert them; but I cannot affirm that it contributed to their recovery. To the convalescent, however, it proved advantageous." A more recent writer (Dr. Conolly) also observes[1], that "little regard is probably due to music as a remedial means, its effects being usually only temporary. Violent patients often become silent, and then moved to weeping, when the piano is played to them." As, in the therapeutical employment of music in insanity, our object is to create agreeable emotions, by recalling the happy events of by-gone times, and by restoring old associations and trains of thought, particular attention should be paid to adapt the character of the music to the peculiarities of each case; for it is obvious that what may prove beneficial to one patient may be injurious to another.

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[1] See Dr. Haygarth's *Of the Imagination as a Cause and a Cure of Disorders of the Body, exemplified by fictitious Tractors and epidemical Convulsions*, in the *London Medical Review*, vol. iii. p. 28, 1800, also, Dr. Lind's *Treatise on the Scurvy*, p. 343 et seq. and p. 535, 3d ed. 1772.

[2] See Dr. Wm. Falconer's *Dissertation on the Influence of the Passions upon Disorders of the Body*, p. 100, 2d ed. Lond. 1791.

[3] On this subject consult Esquirol, *Des Maladies Mentales*, t. ii. p. 743, Paris, 1838. Also, Prichard's *Treatise on Insanity*, ; and Dr. Conolly *On the Advantages and Disadvantages of Removal of the Patient from Home*, in the *Lancet* for April 25th, 1846.

[4] For an account of the *non-restraint* system pursued at Hanwell, see Dr. Conolly's Lectures in the *Lancet* of Nov. 1, 1845. In cases of great violence, seclusion in a padded room is substituted for bodily coercion.

[5] F. A. Steinbeck, *Diss. Inaug. de Musices atque Poësos*, Berol. 1826.

[6] 1 *Samuel*, xvi. 15—23.

[7] *Des Maladies Mentales*, t. ii. p. 538, Paris, 1838.

Reasoning, with nervous, hypochondriacal, and insane patients, rarely proves serviceable. This arises chiefly, perhaps, from the circumstance that the malady in these cases is more frequently seated in the feelings than in the understanding; and wherever strong feelings are deranged, little effect is to be expected from reasoning. In many instances it is absolutely injurious, "by exciting irritation in the mind of the sufferer, who thinks his counsellors are either unfeeling or incredulous towards his complaints[2]."

PART II.—PHYSICAL BUT IMPONDERABLE REMEDIES.

(*Remedia physica.*)

In this part we have to consider Light, Heat, Electricity, and Magnetism as remedial agents.

1. LUX.—LIGHT.

(*Lumen.*)

PROPERTIES OF SOLAR LIGHT.—Solar light possesses several distinct properties or qualities: it illuminates bodies; it raises their temperature; it effects in them various chemical changes; and, on some, it confers the faculty of being self-luminous or phosphorescent.

To account for these properties, the *corpuscular hypothesis* assumes the existence of as many kinds of imponderable matter as there are classes of properties. Thus the illuminating quality is ascribed to an imponderable termed light, the calorific property to caloric, the chemical property to tithonicity[3], and the phosphorogenic property to an imponderable which has not hitherto received a name[4]. But the *undulatory hypothesis* explains the phenomena by assuming the existence of one imponderable or etherial medium, to the mechanical action of whose vibrations or undulations on the atoms of matter all these properties of solar light are ascribed; the differences in the effects of this action depending on differences in the frequency of the undulations. Of the undulations which excite the sensation of colour, the shortest and most frequent are assumed to produce the sensation of violet; while the longest and least frequent give rise to the sensation of red. The greatest chemical effects are supposed to result from undulations which are more frequent, but shorter, than those which give rise to the greatest calorific effects. Lastly, the phosphorescence is supposed to arise from the neutralisation of the two electricities which are separated from each other by the mechanical action of the undulations on the atoms of the phosphorescent body[1].

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[1] *The Report of the Resident Physician of the Hanwell Lunatic Asylum, presented to the Court of Quarter Sessions for Middlesex, at the Middlesex Sessions*, 1840.

[2] *Change of Air, or the Pursuit of Health and Recreation, illustrating the beneficial influence of bodily exercise, change of scene, pure air, and temporary relaxation, in sickness and in health*, by James Johnson, M.D. 4th ed. 1838.

[3] *Tithonicity*, from Tithonus, a beautiful youth with whom Aurora fell in love! (Draper, *Lond Edinb. and Dubl. Phil. Mag.* vol. xxi. 1842).

[4] Draper, *op. cit.* vol. xxv. 1844.

PHYSIOLOGICAL EFFECTS.—In the organised world, light performs important functions, and acts as a vivifying or vital stimulus[2]. This physiological property may be a primary or secondary quality of light; that is, it may be an influence distinct in its nature from any of the physical properties already alluded to, or it may be a consequence of them.

Morning light is popularly believed to exercise a more beneficial influence on the nutrition of animals and plants than afternoon light. If this notion be well founded, it lends support to the opinion that the physiological effects of light are connected with the chemical influence of this agent; for, in photographical experiments, it is usually found that the rays of the morning sun are more effective than those of the afternoon sun.

Light promotes the nutritive processes of vegetables, and is the cause of the green colour of plants. That curious phenomenon denominated the *sleep of plants* is supposed to be connected with the absence of light. A morbid condition, called *etiolation*, or *blanching*, is observed in vegetables which grow in obscure places[3].

On animals, light operates in a two-fold manner: it promotes their development and nutrition, and it acts as a specific stimulus to the eye, as the organ of vision[4].

Privation of light disposes to inactivity and sleep. Edwards found that it retarded or prevented the hatching of the ova of frogs. The disease, called *Anæmia* or *Hypæmia* in man, is analogous to the condition termed etiolation in vegetables; and, like the latter, is sometimes referable to deprivation of light, combined, however, with other deleterious causes[5].

Amaurosis (retinitis?) occasionally results from the exposure of the eye to strong light. The effect of the sun-stroke (*coup de soleil*, or *ictus solaris*), in inducing inflammation of the brain, may be, in part, perhaps, owing to the influence of the light of the solar rays.

USES.—In maladies characterised by imperfect nutrition and sanguification, as scrofula, rickets, and anæmia, and in weakly subjects with œdematous limbs, &c. the exposure to solar light is sometimes attended with very happy effects. Open and elevated situations probably owe part of their healthy qualities to their position with regard to it. The observations of Dr. Edwards, on the influence of light in promoting the perfect development of animals, led him to conclude, that in climates where nudity is not incompatible with health, exposure of the whole surface of the body to light is favourable to the regular conformation of the body; and he has, therefore, suggested insolation in the open air as a means calculated to restore healthy conformation in scrofulous children whose deviations of form are not incurable[1].

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[1] E. Becquerel *On the Constitution of the Solar Spectrum*. In Taylor's *Scientific Memoirs*, vol. iii. 1843.

[2] The phrase *vivifying* or *vital stimuli* is used to designate those external conditions necessary to the maintenance of life in organised beings; such as heat, air, water, and nutriment. They are to be distinguished from the *alterative* or *medicinal stimuli*, which, while they cause temporary excitement, ultimately exhaust (see Müller's *Elements of Physiology*, by Baly, vol. i. pp. 28 and 57).

[3] For details respecting the influence of light on vegetation, consult J. C. Ebermaier, *Versuch einer Geschichte des Lichtes*, Osnabrück, 1799; Landgrebe, *Ueber das Licht, vorzugsweise über die chemischen und physiologischen Wirkungen desselben*, p. 187, Marburg, 1834; R. Hunt, *Researches on Light*, Lond. 1844; Gardner (of America), *Lond. Edinb. and Dubl. Phil. Mag.* vol. xxiv. 1844. Also, De Candolle, *Physiologie végétale*, t. iii. p. 1069, Paris, 1832.—Stark, in his *Allgem. Pathol.* p. 211, Leipzig, 1838, gives a complete account of the literature of this subject.

[4] On the influence of light on animals, see J. C. Ebermaier, *op. supra cit.*; E. Horn, *Ueber die Wirkungen des Lichts auf den lebenden menschlichen Körper*, Königsberg, 1799; Landgrebe, *op. supra cit.* p. 370; and W. F. Edwards, *De l'Influence des Agens physiques sur la Vie*, p. 394, Paris, 1824.

[5] See the case of the workmen employed in a French coal-mine, detailed in the *Dictionnaire de Médecine*, art. *Anémie*; and M. Andral's *Treatise on Pathological Anatomy*, translated by Drs. Townsend and West, vol. i. p. 97.

1. *Darkness.*

In all diseases of the eye attended with local vascular or nervous excitement, in inflammatory conditions of the brain, in fever, and in mental irritation, whether attended or not with vascular excitement, the stimulus of light proves injurious, and, in such cases, darkness of the chamber should be enjoined. After parturition, severe wounds, and surgical operations, and in all inflammatory conditions, exclusion of strong light contributes to the well-doing of the patient. Lastly, darkness is employed to promote sleep[2]. In most cases where obscurity is indicated, rest and quietude should be enjoined.

2. *Dioptric Instruments.*

When vision is imperfect from defect of focal distance, *i. e.* from some defect of the image-forming parts of the eye, the remedy consists in the use of dioptric or refracting instruments (*eye-glasses; spectacles*). In *myopia* (i. e. *short-* or *near-sightedness*), double concave lenses are usually employed to counteract the over refractive power of the humors; while, in *presbyopia* (*long-* or *far-sightedness*), convex lenses or magnifiers are generally used to obviate the diminished refractive power of the humours of the eye[3]. These are generally double convex glasses; but, for couched eyes, plano-convex glasses are frequently employed, in order to give a larger field of vision.

Lenses, for the above purposes, are commonly made either of flint-glass or of Brazilian quartz[4]. The latter, called *pebble*, has the advantage of greater hardness, and it is not, therefore, so readily broken or scratched[5]. The diathermancy of quartz is about the same as that of mirror-glass[6].

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[1] *Op. supra cit.* p. 401.

[2] See p. 4.

[3] In opticians' shops two *trial boxes*, or *frames of sight*, are kept; the one comprises the range of double convex, the other of the double concave lenses. These are used for trying myopic or presbyopic eyes.

[4] Quartz presents some remarkable optical phenomena. It possesses the property of double refraction in the direction of its axis. In this it differs from every other known uniaxial crystal. Moreover, when a plane-polarised ray is transmitted through a prism of quartz, the two pencils, into which the ray is divided, are, at their emergence, elliptically polarised (Airy, in *The Transactions of the Cambridge Philosophical Society*, vol. iv. 1833).

[5] Lenses made of amber are readily scratched, and soon lose their polish.

[6] Melloni, *Taylor's Scientific Memoirs*, vol. i. p. 1. The transcalency or diathermancy of several transparent solids is as follows:—

Of 100 rays of heat proceeding from the flame of an Argand lamp, there were transmitted by

	Rays transmitted.		*Rays transmitted.*
Rock salt	92	Mirror glass	62
Iceland spar	62	Alum	12
Quartz	62	Sulphate of copper (diaphanous)	0

In another series of experiments Melloni ascertained the relative diathermancy of flint-glass, mirror (plate) glass, and crown-glass, to be respectively 65, 62, and 49.

Occasionally lenses of other forms than those above enumerated are employed; but the only one deserving of special notice is the *periscopic* or *meniscus* (concavo-convex) lens, recommended by Dr. Wollaston[1], for enlarging the field of vision[2].

Double Convex Lenses, for Long-sightedness.			Convex Lenses, for Couched Eyes; or Cataract Glasses.		Double Concave Lenses, for Short-sightedness.		
Sights.	*Inches Focus.*		*Inches Focus.*		*Nos.*	*Inches Focus*[3].	
000	60	Rarely used.	2	For reading.	000	36	Rarely used.
00	48		2¼		00	30	
0	40		2½		0	24	
First	36		2¾		1	20	
Second	30		3		2	16	
Third	24				3	14	
Fourth	20		3½	For distant objects.	4	12	
Fifth	16		3¾		5	10	
Sixth	14		4		6	9	
Seventh	12		4¼		7	8	
Eighth	10		4½		8	7½	
Ninth	9		4¾		9	7	
Tenth	8				10	6	
Eleventh	7				11	4¾	
Twelfth	6				12	4¼	
Thirteenth	5				to 20		

3. *Chromatic Instruments.*

In some affections of the eye (popularly known as *weakness of sight*), coloured glasses are employed, with occasional relief, to diminish the intensity of light. Those with a neutral or gray tint (or twilight tinge), recommended by Mr. Mayo[4], prove the most agreeable to the eye.

White light is most fatiguing and hurtful to the eye[5]. The disease called snow-blindness, which sometimes results from the long contemplation of a country covered with snow, is probably retinitis[6].

Both *red* and *yellow*[7] light are injurious to the eye. To the excess of the yellow and red rays in common artificial light, may be in part ascribed the baneful influence of this light in causing impaired vision. Two modes of preventing its ill effects have been suggested; viz. the addition, by reflection, of the blue rays that are deficient (as by the use of conical blue shades or reflectors around the flame); or the subtraction, by absorption, of the red or yellow rays that are in excess (as by passing the light through blue glass, or some other transparent medium of a blue tint[8]).

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[1] *Nicholson's Journal*, vols. vii. and viii.

[2] For further information respecting spectacles, consult Mackenzie's *Practical Treatise on Diseases of the Eye*, pp. 784 and 792, 3d edit. Lond. 1840; Kitchener's *Economy of the Eyes*, Part 1—Spectacles, 2d edit. Lond. 1826; and Cox's *Spectacle Secrets*, Lond. 1838.

[3] A concave glass of a given number of inches focus is considered to be equivalent to a convex glass of the same number of inches focus; because, when superposed, the refraction of the one exactly neutralises that of the other.

[4] *The Philosophy of Living*, Lond. 1838.

[5] The intense light caused by the ignition of charcoal and the combustion of metals effected by the voltaic battery constructed by Mr. Grove, has produced on myself, as well as on some friends, temporary blindness. The symptoms (which lasted two days in my case) were those of retinitis, with profuse lachrymation.

[6] Mackenzie, *op. supra cit.* p. 501.—Xenophon (*Anabasis*, lib. iv.) speaks of snow-blindness.

[7] Hence, amber lenses, as well as amber-coloured glass lenses, are objectionable.

[8] See Dr. James Hunter's work, *On the Influence of Artificial Light in causing impaired Vision*, Edinburgh, 1840.

Green, blue, indigo, and *violet* lights are much less injurious than either red or yellow. Spectacles of these colours have been made for the use of those suffering with sensitive eyes; but they are inferior to the neutral tint before mentioned; since, after their removal from the eyes, every object sometimes presents for a short period complementary tints; shewing that these colours have fatigued the retinæ.

All dark-coloured glasses, however, and especially black crape spectacles, are objectionable, on account of their greater power of absorbing and radiating caloric, by which they prove heating to the eyes[1].

2. CALOR.—HEAT.

PHYSIOLOGICAL EFFECTS.—All living beings, but especially the animals denominated *warm-blooded,* generate heat. To all a certain temperature (which differs in different individuals) is essential to the maintenance of life; and hence caloric or heat is a vital stimulus[2]. Increased beyond a certain degree, it ceases to be vivifying: it may cause inflammation or apoplexy; it may exhaust by its prolonged stimulant operation; or, when its action is very violent, it may decompose the organised tissues by its chemical influence.

The effects of caloric on living beings are threefold, viz.:—

1. PHYSICAL; including *expansion* or *dilatation, fluidity,* and *augmented temperature.*
2. CHEMICAL; comprising *increased tendency to changes of composition* and *decomposition.*
3. DYNAMICAL, PHYSIOLOGICAL, or VITAL; comprehending all *changes in the condition of the vital properties* produced by heat. These changes are of two kinds,
    - α. *Primary;* exaltation, excitement, or augmentation, of vital action.
    - β. *Secondary;* exhaustion, or diminution, of vital action.

a. On Vegetables.—A certain degree of heat promotes all the vital processes of plants. It accelerates germination, the growth and development of all vegetable organs, inflorescence, fecundation, and the ripening of the fruit; and it quickens the movements of parts susceptible of motion. Too elevated a temperature, accompanied with dryness, deranges the health of plants[3]; and an intense heat decomposes the vegetable tissues.

b. On Man and other Animals[4].—A certain degree of external heat (different in different beings) promotes the vital manifestations of animals, and hence we denominate it an excitant or stimulant. Its prolonged operation, however, is followed by debility and exhaustion proportionate to the previous excitement.

α. *Effects of heat applied topically.*—The effects of topical heat are, first, a sensation of warmth, redness, turgescence, and a slight augmentation of temperature of the part heated. The diameters of the minute capillary vessels expand under the influence of caloric, and thus the red blood-disks are enabled to enter tubes which were previously impervious to them. The augmented volume of the part arises, therefore, in a great measure from the presence of an increased quantity of blood; but in part also from the physical

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[1] Melloni (*op. supra cit.*) ascertained the diathermanous properties of coloured glasses to be as follows:

Of 100 incident rays, there are transmitted by

Coloured glass.	*Rays transmitted.*	*Coloured glass.*	*Rays transmitted.*
Deep violet	53	Bright yellow	34
Vivid red	47	Mineral green	23
Clear blue	42	Very deep blue	19

[2] See foot-note at p. 8.

[3] De Candolle, *Physiologie Végétale,* t. iii. p. 1098.

[4] See Stark's *Allgem. Pathol.* S. 226 and 1170, Leipzig, 1839, for the literature of this subject.

dilatation of the solids and fluids caused by their augmented temperature. The living tissues become more relaxed, soft, and flexible, under the influence of a moderate heat, and admit of a more rapid transpiration.

A more violent degree of heat causes burning pain, redness, and vesication. A still more intense heat destroys vitality and organisation. Whenever a large portion of the surface of the body is destroyed (as in burns and scalds), great constitutional disturbance, or even death, results from the shock given to the nervous system. Acute ulceration of the duodenum is not an infrequent cause of death in cases of severe burns[1].

β. *Effects of heat applied to the whole body.*—If the whole body be subjected to an elevated temperature, not incompatible with prolonged life, its effects are manifested first in the vascular system, and in the organs connected therewith. The superficial vessels enlarge; the skin becomes redder; and the pulse quicker and fuller: respiration is more frequent; the animal heat is augmented; and the expired air is hotter, and more loaded with vapour.

Increased exhalation (first of insensible and vaporous matter, then of visible and liquid sweat) and augmented secretion of the periphery soon succeed. The rapid conversion of a liquid into an aeriform fluid (insensible perspiration) is attended with the production of cold; and thus animals are enabled to counteract external heat, and to maintain nearly their original temperature, when exposed to a temperature considerably higher than that of their own bodies, by the increased perspiration which they suffer under these circumstances. The determination of the surface, and the increased transpiration and secretion of the skin, are attended with a contemporaneous diminution of activity in some of the internal organs. Thus, the secretions of the kidneys and of the mucous membranes are diminished in consequence of the increased secretion and exhalation of the skin.

The mutually-antagonizing influence of determinations of blood to different parts—as well as of the secretions of different tissues—is a circumstance the knowledge of which is of great practical value in therapeutics[2].

The augmented secretion of bile, and the tendency to hepatic diseases, so commonly observed in Europeans when they become residents in warm climates, are other effects of the continued operation of heat on the body[3].

That heat, aided by inactivity and excess of food, is capable of inducing hepatic disease, is well shown in the case of the goose. The celebrated *pâtés de foies gras*, prepared at Strasburg and Metz, are made from the artificially enlarged livers of geese. The birds are shut up in coops, within heated rooms, and are frequently crammed with food.

Relaxation of the living tissues is another consequence of the employment of moderate heat. This effect, which is best observed when moisture is conjoined with caloric, commences first in the part to which heat is applied: and, when the whole surface of the body has been subjected to an increased temperature, its relaxing influence soon extends to internal parts: hence arise atony, diminution of muscular power, a feeling of languor or fatigue, and an indisposition to corporal exertion.

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[1] See Mr. Curling's cases in the *Med. Chir. Trans.* vol. xxv. p. 260.

[2] See some valuable remarks on the "*antagonism*" of the secretions, in Müller's *Elements of Physiology*, by Dr. Baly, vol. i. p. 473.

[3] Liebig (*Animal Chemistry*, pp. 23 and 24, Lond. 1842) regards hepatic diseases as diseases "arising from excess of carbon."

The primary effect of moderate heat on the nervous system is excitation; the secondary effect, exhaustion. In the first instance sensibility is agreeably promoted, the action of the voluntary muscles assisted, and the intellect somewhat exalted. But to these effects succeed languor, relaxation, listlessness, indisposition to corporal and mental labour, and tendency to sleep.

The languor, indolence, and relaxed fibres, so commonly observed in the inhabitants of tropical climates, are probably to be ascribed in a great measure to the exhausting and enervating influence of external heat.

Lastly, the prevailing maladies of hot climates may be referred to as farther illustrations of the effect of continued heat on the body. Fevers, diarrhœa, dysentery, cholera, and liver diseases, may be regarded as the special maladies of the burning equatorial regions.

The exhaustion which follows the excitation caused by heat and other stimuli, would seem, to use the words of Müller[1], to "show that the organic force is consumed, as it were, by the exercise of the functions;" and, to employ a simile of Dr. Priestley[2], we may say, that as a candle burns out much faster in oxygen gas than in air, so we may be said to live out too fast when under the exciting influence of an elevated temperature.

USES.—As a remedial agent, heat serves several important purposes. It is employed—

1st. To produce local or general excitation of the nervous and vascular systems.

a. To restore the circulation and temperature to their natural standard. *Examples.*—Bottles of hot water to the feet in coldness of the extremities; warm or hot baths in asphyxia from drowning, in collapse from cholera, fevers, &c.; warm baths, or exposure to the rays of a common fire, in old paralytic cases with feeble circulation and cold extremities.

b. To equalise the distribution of blood, and thereby to check a preternatural afflux to other organs. *Examples.*—Warm applications to the feet to relieve determinations of blood to the brain; warm baths in some internal diseases attended with coldness of surface, or which appear to be connected with the disappearance of a cutaneous eruption; warm baths and fomentations in gastritis, enteritis, cystitis, and nephritis.

2ndly. To re-establish or augment secretion and exhalation.

a. To promote diaphoresis. *Examples.*—Warmth to the skin to promote the operation of sudorific medicines; warm baths and warm clothing in diabetes relieve the dry and unperspirable state of skin, and check the excessive secretion of urine; they are also important remedial agents in granular disease of the kidney; warm vapour and water baths in colds, rheumatic affections, scaly diseases, &c.

b. To promote menstruation. *Example.*—Warm baths in amenorrhœa.

c. To promote exhalation and secretion from the air-passages. *Example.*—Inhalation of warm aqueous vapour in irritable conditions of the air-passages.

3rdly. To relax tense, rigid, or spasmodically-contracted tissues.

a. To reduce the contractile power and tension of muscular and other tissues, and thereby to favour the reduction of dislocations and herniæ. *Example.*—Warm baths previous to the attempted reduction of old dislocations and of strangulated herniæ.

b. To soften tissues which are preternaturally rigid. *Example.*—The warm bath, with shampooing, in rheumatic stiffness and rigidity.

c. To relax spasm. *Examples.*—Warm baths and fomentations in tetanus, colic, passage of urinary or biliary calculi, spasmodic retention of urine, &c.

4thly. To sooth and alleviate pain, whether inflammatory, spasmodic, or neuralgic.

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[1] *Op. cit.* vol. i. p. 52.

[2] *Experiments and Observations on different kinds of Air*, vol. ii. p. 169, Birmingham, 1790.

a. To alleviate inflammatory pain. *Examples.*—Warm water and poultices to burns and scalds, to inflamed and suppurating parts, ulcers, inflamed piles, &c. They relax tissues, and thereby relieve pain from tension.

b. To allay spasmodic pain. *Examples.*—Warm baths and fomentations in strangury, colic, passage of calculi, &c.

c. To allay neuralgic pain. *Examples.*—Fomentations in toothache, faceache, earache, &c.: warm baths in neuralgic dysmenorrhœa, &c.

5thly. To promote the termination of inflammation and its consequences by facilitating certain organic changes.

a. To promote the resolution of inflammation. *Example.*—Warm fomentations and poultices to inflamed parts.

b. To promote suppuration. *Example.*—Warm fomentations and poultices to boils.

c. To further the escape of pus from abscesses. *Example.*—Poultices to abscesses after they have been opened.

d. To promote the separation of sloughs. *Example.*—In some forms of gangrene poultices are useful by promoting the throwing off of the slough.

6thly. To burn or destroy chemically.

a. To destroy poisonous substances introduced into the living tissues. *Example.*—The actual cautery in bites by rabid animals.

b. To destroy morbid growths. *Example.*—The actual cautery to destroy fungus of the antrum.

c. To stop hemorrhage. *Example.*—A hot iron applied to the mouth of the wounded vessel or vessels.

d. To produce revulsion or counter-irritation. *Examples.*—Steam, boiling water, heated metals, moxa, &c. applied to the skin to relieve diseases of internal parts.

e. To open abscesses, close fistulous sores, &c. *Example.*—The actual cautery is occasionally applied in these cases.

CONTRAINDICATIONS.—The most important circumstances which contra-indicate the employment of heat are—

1. Great vascular excitement, plethora, aneurism, dilated heart, hemorrhage, &c.
2. Great relaxation and flabbiness, especially in the superficial organs.
3. Profuse secretion and exhalation.
4. Great nervous excitability with little power.

METHODS OF AUGMENTING THE TEMPERATURE OF THE BODY.—There are three modes of promoting or raising the temperature of the body:—

1. By communicating sensible heat from without, either by the application of heated substances to the body, or by the introduction of radiant heat.
2. By diminishing the cooling influence of surrounding bodies; as by the use of clothing made of substances which are bad conductors of caloric.
3. By augmenting the generation of animal heat within the body; as by active exercise, friction, and the use of medicines or foods which accelerate circulation and respiration.

Of these three methods, the first is the one which is the special object of our present inquiries.

The communication of heat to the body may be effected either by *radiation* or *conduction*. *Radiant heat* may be derived either from the sun, or from artificially-heated substances. *Conducted heat* may be derived from either dry or moist substances, and its effects vary somewhat as it comes from the one or the other of these sources.

1. Radiant heat:—
    - *a.* From the sun (*solar heat*).
    - *b.* From artificially-heated substances (*artificial radiant heat*).
2. Conducted heat:—
    - *a.* From dry substances (*dry heat*).
    - *b.* From moist substances (*moist heat*).

1. RADIANT HEAT.

1. SOLAR HEAT.—The ancients[1] were well acquainted with the salutary influence of solar heat on the human frame, and frequently employed it for therapeutical purposes.

Exposure to the solar rays, or, as it is termed, insolation (*insolatio*, *apricatio*, *solicatio*, *heliosis*—ἡλίωσις), may be employed as a stimulant to promote circulation and warmth, in the old, debilitated, and paralytic. It is also valuable in scrofula and anæmia, and as a restorative after lingering and painful maladies.

The head should be carefully guarded from the direct influence of the sun, in order to prevent the occurrence of the *sun-stroke*, or *ictus solaris*, before referred to. The skin also should be protected, to prevent the production of erythema or erysipelas, which sometimes arises from the direct action of the sun on the naked skin.

Faure employed the solar rays, concentrated by a burning glass, to stimulate indolent ulcers, especially those which follow frost-bites. Formerly cauterisation was effected in the same way[2].

2. ARTIFICIAL RADIANT HEAT.—Exposure to the rays of a common fire is resorted to, as a stimulant and calefacient, in old paralytic and other cases attended with coldness and blueness of the extremities, and with other symptoms of insufficient circulation of the blood.

The heat radiating from a burning body (as a candle), or ignited iron, is sometimes employed as a stimulant to produce rubefaction in the tract of the vertebral column, in paralytic and neuralgic affections of the spinal cord. "A much more durable impression of heat," observes Müller[3], "better than moxa or the actual cautery, is produced by holding a burning candle near to the affected part for a long time, so as to produce pain; by which means all the beneficial effect of heat is obtained, without the formation of an eschar and the subsequent suppuration, which is often of no service. The mode in which the caloric acts in these cases is not evident."

The radiant heat from a red-hot iron or burning coal has been employed as a cautery to check hemorrhages, and to promote the reduction of prolapsus of the rectum and uterus, and of hernia. This practice constitutes the *cautérisation objective* of the French writers.

2. CONDUCTED HEAT.

a. *Dry Heat.*

Under the head of *dry heat* (*calor siccus*) are included hot air, bottles filled with hot water, hot sand, &c.

1. HOT AIR BATH.—Air, at a temperature of from 100° to 130° F. is stimulant and calefacient, but is less relaxing and soothing than moist vapour. When required to operate as a sudorific, a temperature of from 90° to 100° F. (Dr. Gower says 85°) is found most advantageous. The hot air bath is

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[1] Hippocrates, *De Morbis*, lib. ii. 66 and 68; Celsus, lib. i. cap. 2 and 3; Cælius Aurelianus, *Morb. Chronic.* lib. iv. cap. 2.

[2] Marjolin, in *Dict. de Médecine*, art. *Cautérisation*. Most, in his *Encyklopädie der gesammten medicin. u. chirurg. Praxis*, Leipzig, 1837, art. *Insolatio*, cites Dresig, *De solicatione, vulgo insolatione veterum*, Lips. 1737; and Richter, *Diss. Insolatio, seu potestas solis in corpus humanum*, Götting. 1747.

[3] *Op. cit.* vol. i. p. 59.

applicable as a remedial agent when the blood has receded from the superficial parts of the body, and the internal organs are in a state of congestion; as in some forms of fever, and in spasmodic cholera; and also in asphyxia from drowning, and from some other causes. But it is inferior, for these purposes, to either hot water or hot vapour baths. It has been used also in chronic rheumatism, stiffness of the joints, and chronic skin diseases, especially the dry scaly eruptions[1].

The *medicated hot air bath* is prepared by impregnating the hot air with some gas or vapour; as with sulphurous acid gas, or chlorine[2].

2. SOLID SUBSTANCES WHOSE TEMPERATURE DOES NOT EXCEED 100° F.—*Bottles filled with hot water* are applied to the feet to excite the circulation and augment the warmth of the body, in various diseases attended with cold extremities. The same remedy is conveniently applied to the abdomen, to remove spasmodic pain. *Hot sand* (*arena calida*), enclosed in a bag or bladder, may be employed for similar purposes. It is used as a bath[3] in the maritime departments of the South of France[4]. It operates as a stimulant and sudorific, and is employed in rheumatism, spasm, paralysis, &c.[5] *Hot ashes* or *bran* have been applied to similar uses; as also *hot bricks*. *The leaves of the common birch* (*Betula alba*) are employed in Sweden[6].

The animal heat of young and healthy persons (*accubitus junioris*) has also been employed in cases of extreme exhaustion with great depression of the temperature of the body, especially in the aged It is a very ancient practice, having been adopted in the case of King David[7]. Sydenham was particularly partial to it, and speaks of its efficacy with great confidence. He says the heat applied by it is more agreeable, bland, moist, equal, and permanent, than that of hot clothes[8]. *The warm skin of a recently-killed animal*, particularly that of a sheep, wrapped round the body of the patient, the wool outwards, has likewise proved advantageous[9].

3. METAL HEATED TO 212°.—The late Sir Anthony Carlisle[10] proposed to

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[1] For farther information respecting the hot-air bath, consult the *Cyclopædia of Practical Medicine*, vol. i. p. 266, art. *Warm-Air Bath*, by Dr. Forbes.—Also Dr. Gower's *Auxiliaries to Medicine*, Lond. 1819, Tract 1, *An Account of the Sudatorium*.

Various easy modes of making a hot-air bath have been suggested. A very simple method is that recommended by Mr. Alcock (*Lancet*, 1825-6, vol. ix. p. 862). It consists in burning spirit in a cup or saucer under a blanket; the patient lying on the bed with his head and face outside the blanket, as the air is not fit for respiration. The blanket is supported over the bed by a cord.

[2] See *Chlorine* and *Sulphurous Acid*.

[3] The phrase *balneum arenæ* is incorrect. Celsus (lib. ii. cap. 17) limits the term *balneum* to a water-bath artificially heated in a private house.

[4] Schwilgue, *Traité de Matière Médicale*, t. ii. p. 324.

[5] The practice of sand-bathing, called *saburration* or *arenation* (*saburratio*, *arenatio*, vel *psammismus*, *ψαμμισμός*, from *ψάμμος*, sand,) is very ancient (Quiring, *De balneis arte parandis. Diss. Inaug*. Berol. 1837; Sutherland, *Attempts to revive Antient Medical Doctrines*, vol. i. p. 48, Lond. 1763). It is allied to mud-bathing or *illutation* (*illutatio*), hereafter to be noticed. Lind (*Treatise on the Scurvy*, 3d ed. 1772, p. 534,) mentions a common practice among the Buccaneers, in the West Indies, of *burying in the ground* (the head being left above ground) patients affected with scurvy. They were permitted to remain thus interred for several hours, until a profuse sweat ensued. I have recently had under my care, in the London Hospital, a sailor who had been twice thus buried in the West Indies for the cure of scurvy!!

[6] Bergius, *Materia Medica*, t. ii. 778, ed. 2da, Stockh. 1782.

[7] 1 *Kings*, ch. i. 1—4.

[8] Sydenham, *Opera omnia*, ed. G. A. Greenhill, M.D. Lond. 1844, p. 55.—Also *Anecdota Sydenhamiana*, p. 62, Oxford, 1845.

[9] Copland, *Dict. of Pract. Med.* vol. iii. p. 135.

[10] *Lancet*, 1826-27, vol. xi. p. 315 and 384.

excite speedy vesication by the application to the skin of a polished plate of metal heated to 212° by immersion in boiling water. He recommended it as a substitute for cantharides, than which he declared it to be less painful; while it is not liable to cause strangury.

4. THE ACTUAL CAUTERY (*Cauterium actuale*).—Several agents have been employed as actual cauteries, viz. *red-hot iron*, *moxa*, and the *flame of hydrogen*. The first, however, is the one generally referred to under the name of the actual cautery. The two latter will be noticed in subsequent parts of the work[1].

In this country the actual cautery (red-hot iron) is seldom used. It is sometimes resorted to as a styptic, when the hemorrhage is from a great number of small vessels, or from a vessel so situated that the ligature cannot be applied. It is also used to destroy morbid growths which cannot be reached by the knife—as fungus of the antrum; to stop caries, to excite an artificial ulcer, to open abscesses, to close fistulous ulcers, to decompose the venom or poison in bites by poisonous or rabid animals, and, in epilepsy, to destroy the part from whence the aura epileptica sets out[2].

3. Moist Heat.

Under the head of *moist heat* (*calor humidus*) are included *warm aqueous vapour*, *warm water*, and *warm moist solids*.

a. Aqueous Vapour.

1. THE VAPOUR BATH.—The general effects of the vapour bath are those of a powerful stimulant and sudorific. It softens and relaxes the cutaneous tissue, expands the superficial vessels, accelerates the circulation of blood, augments the frequency of the pulse and respiration, and produces copious perspiration. These effects are succeeded by a feeling of languor, and a tendency to sleep.

If the whole body be immersed in vapour, which is consequently inhaled, the temperature should be a little less than if the trunk and limbs alone are subjected to its influence; because the inhalation of vapour stops the cooling process of evaporation from the lungs. The following is a comparative view of the heating powers of water and of vapour, distinguishing the latter according as it is or is not breathed[3]:—

	WATER.	VAPOUR.	
		Not breathed.	*Breathed.*
Tepid bath	85° — 92°	96° — 106°	90° — 100°
Warm bath	92 — 98	106 — 120	100 — 110
Hot bath	98 — 106	120 — 160	110 — 130

The vapour bath is distinguished from the hot air bath by its soothing, elaxing, and greater sudorific influence: from the hot water bath, by its inferior power of communicating heat, by its greater sudorific tendency, and by its causing scarcely any superficial compression of the body, whereby it does not occasion the præcordial oppression experienced on entering the water bath.

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[1] See *Hydrogen*, and *Artemisia Moxa*.

[2] For further details respecting the actual cautery and cauterisation, see Percy's *Pyrotechnie hirurgicale pratique*, Paris, 1811, Marjolin, art. *Cautère* and *Cautérisation*, in the *Dict. de édecine*; and Sanson, in the *Dict. de Méd. et Chir. pratiques*.

[3] Dr. Forbes, *Cyclopædia of Practical Medicine*, art. *Bathing*, vol. i. p. 265.

The vapour bath, like the hot air bath, may be employed when the blood has receded from superficial parts, and congestion of internal organs has in consequence occurred; as during the cold stage of intermittent fever, in malignant cholera, and during the stage of chilliness which ushers in various febrile complaints. But its great value is experienced when our object is to relax the skin, and to produce profuse sweating; as in chronic rheumatism and gout; in slight colds from checked perspiration; and in chronic skin diseases accompanied with a dry state of the cutaneous surface. In old paralytic cases, without signs of vascular excitement of the brain; in some uterine affections, as chlorosis, amenorrhœa, and irritation of the womb; in dropsy of aged and debilitated subjects; in old liver complaints; and in some scrofulous affections, it is occasionally employed with advantage[1].

In this country it is employed for therapeutic purposes only; but in Egypt, Turkey, Persia, and some other parts of the East, and in Russia, it is in common use as a hygienic agent and luxury; and is accompanied by a process of friction, kneading, and extension of the muscles, tendons, and ligaments, constituting the *massing*[2] of the Egyptians, and the *shampooing* of the East Indians. In rigidity and stiffness of joints this process sometimes proves of considerable service.

The *Russian vapour baths* have been long celebrated. The vapour is produced by throwing water over red-hot stones. Its temperature, according to Lyall[3], is from 122° to 144·5° F. ' Besides being exposed to the influence of this vapour, the bathers are subjected to a system of friction, flogging with the leafy branches of the birch, and affusions of warm or cold water. It is customary with them to issue from their bathing-houses, while quite hot, and, in the summer, to plunge into cold water,—in the winter to roll themselves naked in the snow, without sustaining injury or ever catching cold[4]. Bremner[5] describes the supposed bracing effects as being all imaginary; and declares that the practice of bathing followed by the Russians rapidly enervates and undermines the constitution. Several medical writers[6] have borne testimony to the efficacy of the baths in alleviating rheumatism.

The *Egyptian vapour baths* are in constant and general use. The bathers, having been subjected to the operation of *massing* already alluded to, are then rubbed, and afterwards washed[7]. The *Turkish*[8] and *Persian*[9] baths are somewhat similar.

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[1] For a more detailed account of the uses of the vapour bath, the reader is referred to Dr. Gibney's *Treatise on the Properties and Medical Application of the Vapour Bath*, Lond. 1825.

[2] *Masser*, from the Arabic verb *masses*, to touch lightly. See Savary's *Letters on Egypt*, vol. i. p. 130, 2d edit. Lond. 1787.

[3] *Character of the Russians*, p. 112, Lond. 1823.—Mr. Lyall has given a plan of the Russian baths.

[4] Dr. E. D. Clarke's *Travels in various Countries of Europe*, part i. p. 143, et seq.

[5] *Excursions in the Interior of Russia*, vol. i. p. 185, Lond. 1839.

[6] Dr. Granville's *St. Petersburgh*, vol. i. p. 509, Lond. 1828.

[7] For a description and representation of the Egyptian baths, consult *Description de l'Egypte, Etat moderne*, t. ii. (2de partie), p. 683; vol. i. planche 49, and vol. ii. planche 94. Also, Lane's *Account of the Manners and Customs of the Modern Egyptians*, vol. ii. p. 35, Lond. 1837.—Sir J. G. Wilkinson, in his *Manners and Customs of the Ancient Egyptians*, vol. iii. p. 388, Lond. 1837, has given a sketch, from a painting in a tomb at Thebes, representing a lady in a bath, with four attendants.

[8] D'Ohsson's *Tableau Général de l'Empire Ottoman*, t. i. p. 160, Paris, 1787. An engraving of a bath is given.

[9] Fowler's *Three Years in Persia*, vol. i. p. 269, Lond. 1841.

Topical or *local vapour baths* are employed in the treatment of local diseases: as affections of the joints. Dr. Macartney[1] recommends the topical use of vapour, as a soothing and anodyne application, in painful wounds, contusions, and fractures.

The *vapour douche* is a jet of aqueous vapour (whose temperature does not exceed that of a general vapour bath) directed on some part of the body. Its action depends principally on the temperature of the fluid, for its mechanical effects are comparatively trifling. In some affections of the ear, as otitis, otorrhœa, and otalgia, a stream of warm aqueous vapour may be introduced into the meatus auditorius externus with considerable relief. The most ready means of effecting it is by a funnel inverted over a vessel of hot water; the meatus being applied to the orifice of the funnel.

The *medicated vapour bath* is prepared by impregnating aqueous vapour with the odour of medicinal plants.

Sulphurous acid gas, *chlorine gas*, and *the vapours of sulphur, iodine, camphor, &c.* are sometimes employed in conjunction with aqueous vapour: their effects will be described hereafter.

The application of vapour to particular parts of the body has in some cases been accompanied with the simultaneous removal of atmospheric pressure, constituting the *air-pump vapour bath;* which has been employed in gout, rheumatism, and paralysis[2].

2. INHALATION OF WARM VAPOUR.—The inhalation of warm aqueous vapour proves highly serviceable, as an emollient remedy, in irritation or inflammation of the tonsils, or of the membrane lining the larynx, trachea, or bronchial tubes. It may be employed by Mudge's inhaler, or by inspiring the vapour arising from warm water. Various narcotic and emollient substances are frequently added to the water, but without adding much, if any thing, to its therapeutical power. Dr. Paris[3] states that, in some pulmonary complaints, he has been long in the habit of recommending persons confined in artificially-warmed apartments to evaporate a certain portion of water, whenever the external air has become excessively dry by the prevalence of the north-east winds which so frequently infest this island during the months of spring; and the most marked advantage has attended the practice. In rooms artificially heated by hot air stoves, the necessity for this proceeding is still more obvious.

The benefit which pulmonary invalids are said to have derived from a *residence in cow-houses*[4] is principally referable to the moist warm air with which such places are filled[5].

3. STEAM.—Steam is sometimes employed as a powerful rubefacient and caustic. It is applied by a small copper or tin boiler, called an *æolopile* (from *Æolus*, the god of wind, and *pila*, a ball), furnished with a tubular mouth and stop-cock, and heated by a spirit-lamp. Its action on the body is limited by a perforated piece of pasteboard. When applied sufficiently long, it causes

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[1] *A Treatise on Inflammation*, p. 176, Lond. 1838.

[2] *Facts and Observations respecting the Air-Pump Vapour Bath in Gout, Rheumatism, Palsy, and other Diseases*, by Ralph Blegborough, M.D. Lond. 1803. La Beaume, *Observations on the Air-Pump Vapour Bath*, Lond.

[3] *Pharmacologia*, vol. i. pp. 198 and 379, 6th edit. Lond. 1825.

[4] See Dr. Beddoes' *Observations on the Medical and Domestic Management of the Consumptive, on the Digitalis purpurea, and on the Cure of Scrophula*, Lond. 1801.

[5] See Vogt's *Lehrbuch der Pharmakodynamik*, 2er Band, S. 32, 2te Aufl. Giessen, 1828.

an extensive and deep eschar. In this respect its action is similar to that of boiling water, from which it principally differs in the circumstance of having a much larger quantity of specific and latent heat, but a less conducting power; and in the greater facility with which we can limit its effects. It greatly resembles moxa; but its action is less readily localised, and the wound which it causes is less manageable. It has been used as a powerful counter-irritant in diseases of the hip-joint, neuralgic pains, chronic rheumatism, &c. The objections to its employment are the great pain which it causes, and the danger of its effects.

β. Warm Liquids and Moist Solids.

1. BATHS OF TEPID, WARM, OR HOT WATER.—The practice of bathing is of great antiquity, and precedes the date of our earliest records. It was adopted sometimes for the purpose of cleanliness, sometimes for the preservation of health, and frequently as a recreation and luxury. The ancient Hebrews[1] practised ablutions and bathing; as did also the Greeks. Homer[2] on various occasions mentions hot baths and ablutions; and in the writings ascribed to Hippocrates[3], we find baths mentioned, and their effects described. They are also noticed by Celsus[4], Pliny[5], and other Roman writers. Prosper Alpinus[6] says, that the Egyptians employed hot baths for cleanliness and health; and Freind states, that when Alexandria was plundered, in A.D. 640, there were 4000 baths in that city[7]. Among the Persians[8] and Arabians[9] baths were in use; and the ancient Hindoos also employed them[10].

These examples sufficiently establish the great antiquity of the practice of bathing[11].

a. The Tepid Bath has a temperature of from 85° to 92° F. It gives rise to a sensation of either heat or cold, according to the temperature of the body at the time of immersion. It cleanses the skin, promotes perspiration, and allays thirst. It is sometimes employed as a preparative to the temperate, cool, or cold bath. When there is a tendency to apoplexy, the simultaneous immersion in the tepid bath, and affusion of cold water over the head, have been recommended.

b. The Warm Bath has a temperature of from 92° to 98° F. In general it causes a sensation of warmth, which is more obvious when the body has been previously cooled. It renders the pulse fuller and more frequent, accelerates respiration, and augments perspiration. It causes languor, diminution of muscular power, faintness, and a tendency to sleep. As a relaxant, it is employed to assist reduction in dislocations of the larger joints, and in herniæ. In the passage of calculi, whether urinary or biliary, it is used with the greatest advantage: it relaxes the ducts, and thereby alleviates the pain, and facilitates the passage of the concretion. In gastritis, enteritis, cystitis, and nephritis, it proves a valuable and powerful agent. In exanthematous diseases, when the eruption has receded from the skin, in chronic cutaneous diseases, rheumatism, amenorrhœa, and dysmenorrhœa, it is highly serviceable. The *coxæluvium*, or *hip-bath*, is resorted to in inflammatory or spasmodic affections of the abdominal and pelvic viscera, and in amenorrhœa and in dysmenorrhœa. It is also sometimes employed as a substitute for the general bath, where some affection of the lungs, heart, or great vessels, prohibits the use of the latter. The *bidet* is employed in piles, prolapsed rectum, strangury, ischuria, &c. The *pediluvium*, or *foot-bath*, is used as a revulsive or counter-irritant in slight colds; to promote the menstrual and hæmorrhoidal discharges; and for various topical purposes. The *brachiluvium* or *arm-bath*, and *manuluvium* or *hand-bath*, are principally applied in topical affections of the upper extremities.

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[1] *Leviticus*, xiv. 8; 2 *Kings*, v. 10. *Bell. Jud.* lib. i. cap. 33, § 5.

[2] *Iliad*, xxii. 444; *Odyss.* viii. 451. It would appear from Homer, that the offices of the baths were performed by females; though, from a passage in Herodotus (vi. 19), we may infer that this custom was not peculiar to the Greeks.

[3] *De Diæta*, lib. ii. § 35; *De Affectionibus*, § 47.

[4] Lib. i. cap. 3; and lib. ii. cap. 17.

[5] *Hist. Nat.* lib. xxix. cap. 8; and lib. xxxi. cap. 2, et seq. edit. Valp.

[6] *Medicina Ægyptiorum*, lib. iii. capp. 14—19.

[7] *History of Physick*, part i. p. 7, 3d edit. Lond. 1727.

[8] Xenophon, *Cyropædia*, lib. viii. Plutarch, in his Life of Alexander the Great, mentions that this celebrated conqueror was astonished at the sight of the baths of Darius.

[9] Avicenna, *Canon*, lib. iii. fen. xvi. tract. iv. cap. 10.

[10] Royle's *Essay on the Antiquity of Hindoo Medicine*, p. 53, Lond. 1837.

[11] For further information respecting ancient baths, consult *An Account of the Ancient Baths, and their use in Physic*, by T. Glass, M.D. Lond. 1752; and *Attempts to revive Antient Medical Doctrines*, by Alexander Sutherland, M.D. vol. i. p. 12, et seq. Lond. 1763. Also, *De Balneis omnia quæ extant apud Græcos, Latinos, et Arabas*, Venet. 1553; and Montfaucon, *L'Antiquité expliquée et représentée en Figures*, t. iii. part ii. p. 204, 2nde édit. Paris, 1722.

c. The Hot Bath has a temperature of from 98° to 112° F. It causes a sensation of heat, renders the pulse fuller and stronger, accelerates respiration, occasions intense redness of the skin, and subsequently copious perspiration; gives rise to violent throbbing, and a sensation of distension of the vessels of the head, with a feeling of suffocation and anxiety. Long immersion in it sometimes causes apoplexy. Being a powerful excitant, its use requires caution. It is principally employed in paralysis, rheumatism, and some other chronic diseases; also in collapse, &c.

The above remarks apply to common or fresh water baths; but *sea water*, *mineral waters*, and various *medicated wat*[illegible] are employed for general or topical baths. Of the medicated water baths, those in most frequent use are the *nitro-muriatic*, the *iodurelled*, the *salt water*, the *alkaline*, and the *alkaline sulphuretted*. These will be described hereafter. A *decoction* or *infusion of bran*, and a *solution of bichloride of mercury*, have been used as pediluvia. *Milk* and *gelatinous liquids* are employed as nourishing baths. *Blood*, and *the soft parts of recently killed animals*, were formerly used as baths (*balnea animalia*[1]).

Mudbathing, or *illutation* (*illutatio*, from *in*, upon, and *lutum*, mud), is a very ancient practice[2]. The slime of the Nile was formerly in great request for this purpose[3]. The saline mud found on the sea-shore has been employed in very hot weather as a bath, by the inhabitants of Crimea, and especially by the Tartars, against hypochondriasis, scurvy, scrofula, &c. It operates as an excitant and sudorific[4]. *Hot dung* is used in France as a kind of bath against rheumatism, and in Poland against syphilis[5]. *The husk of the grape*, and *the refuse of the olive*, from which the oil has been drawn, undergo fermentation, and, in this state, have been successfully employed in Paris against acute rheumatism[6].

2. WARM AFFUSION.—Warm affusion excites a very unpleasant sensation, followed by chilliness, and often by pulmonary affections. It has, however, been used in mania. It reduces the frequency of the pulse and of respiration,

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[1] See p. 16. Also, Quiring, *op. supra cit.*

[2] See *Sand-bathing*, p. 16, foot-note.

[3] Aetii, *Serm.* i. capp. 1 et 3. Sutherland, *op. supra cit.* vol. i. p. 45, Lond. 1763.

[4] *Bull. des Sc. Méd. de Ferussac*, xiii. 179.

[5] Merat and De Lens, *Dict. de Mat. Méd.* art. *Bain.*

[6] Ibid.

and occasions a tendency to repose; but its effects are much more temporary than those of the warm bath[1].

3. WARM FOMENTATIONS AND POULTICES.—*Warm fomentations* are employed to lessen inflammation, and to relieve pain, tension, and spasm. In inflammation of the abdominal and pelvic viscera, and in strangury, they are highly serviceable. My friend and colleague, Mr. Luke, has for several years employed, at the London Hospital, warm water as an emollient application to burns and scalds. In almost every instance it soothes and mitigates pain. Mr. Luke thinks that it exerts a beneficial influence in mitigating the consecutive inflammation, rendering the after consequences less severe locally, and the reparative process more speedy, than under other modes of treatment. The water has generally been used in the form of fomentations: repeatedly changing the flannels, and taking care that the surface of the skin was exposed to the air as little as possible. But in some cases poultices have also been adopted, and with much benefit; although their weight, when large, has rendered them not so convenient as fomentations; they obviate, however, the evil arising from the frequent renewal of the latter, and the consequent mechanical irritation.

Emollient poultices act as a kind of local bath. They are employed to relieve pain, spasm, and tension, and to promote the termination of inflammation by resolution or suppuration.

A kind of cloth, called *Impermeable Spongio Piline*, composed of a mixture of sponge and wool, felted together so as to form an even and soft fabric, and afterwards rendered waterproof by a coating of caoutchouc, has been recently introduced as a substitute for poultices and fomentation cloths.

4. WARM AQUEOUS DRINKS AND INJECTIONS.—Tepid or warm water is *taken into the stomach* to promote vomiting; to dilute the contents of the stomach, in cases of poisoning by acrid substances; to excite diaphoresis, in rheumatism, catarrh, gout, &c.; and to allay troublesome cough, especially when dependent on irritation at the top of the larynx. Warm water is *injected into the rectum* to excite alvine evacuations; to promote the hæmorrhoidal flux; to diminish irritation in the large intestine, or in some neighbouring organs, as the uterus, bladder, prostate gland, &c.; and to bring on the menstrual secretion. *Thrown into the vagina*, it is used to allay uterine irritation and pain, and to promote the lochial discharge. *Injected into the bladder*, it is sometimes employed to relieve vesical irritation, or to distend the bladder previously to the operation of lithotrity. It has also been *injected into the urethra*, to allay pain, irritation, inflammation, and spasm.

Lastly, Magendie *injected warm water into the veins*, in hydrophobia, but without saving the life of the patients. I have repeated the experiment, but without any successful result. The same remedy has been employed by Vernière[2], to distend the venous system, and thereby to check or stop absorption, in cases of poisoning by those substances (opium, for example,) which operate by getting into the blood. Moreover, warm water is sometimes used as a medium for the introduction of more powerful agents (as emetic tartar) into the circulating system.

5. BOILING WATER.—Water at the temperature of 212° F. is a powerful

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[1] For further details respecting *Affusion*, see p. 29.

[2] Christison's *Treatise on Poisons*, p. 85, 3d edit. 1835.

irritant, vesicant, and cautery; its effects are similar to those of steam, before mentioned. It has been applied to the skin as a powerful counter-irritant in maladies of internal organs, and as a speedy vesicant when the object is to introduce medicinal substances (morphia, for example,) into the system by the cutis vera. But the excessive pain which it gives rise to, the uncertainty of its effects, and the difficulty of localising its action, are great and almost insuperable objections to its use.

3. FRIGUS.—COLD.

PHYSIOLOGICAL EFFECTS.—The general effect of cold on living bodies is a diminution of vital activity; which terminates, if the cold be intense, and its application continued, in death.

The influence of cold is threefold:—

1. PHYSICAL; including *diminution of volume, of temperature,* and *of fluidity.*
2. CHEMICAL; comprising *a diminished tendency to changes of composition,* and *to decomposition.*
3. DYNAMICAL, PHYSIOLOGICAL, or VITAL; comprehending *changes in the condition of the vital properties.*

a. On Vegetables.—The effects of cold on plants are greater in proportion to the combined humidity. The first effect is a certain state of languor or torpor manifested in germination, the growth and development of all the vegetable organs, inflorescence, fecundation, and maturation of the fruit. Cold also favours the disarticulation of articulated parts. Lastly, by an intense frost the aqueous juices freeze: an effect which is often attended with the death of part or the whole of a plant[1].

b. On Man, and other Animals.—The effects of cold on animals are two-fold, viz.:—

1. Direct, primary, or immediate.
2. Indirect, secondary, or mediate.

The direct or primary influence of cold is diminished vital activity. The indirect or secondary influence of moderate cold, applied temporarily, is increased activity of the vital powers, or re-action.

a. Topical Effects of Cold.—The first effect of the application of a cold substance to the body is a sensation of cold, the intensity of which depends on four circumstances, viz.:—

1. *On the temperature of the cold substance.*
2. *On the conducting power of the cooling agent.* Thus, "if, in winter, a person with bare feet were to step from the carpet to the wooden floor, from this to the hearth-stone, and from the stone to the steel fender, his sensation would deem each of these in succession colder than the preceding. Now the truth being that all had the same temperature, only a temperature inferior to that of the living body, the best conductor, when in contact with the body, would carry off heat the fastest, and would, therefore, be deemed the coldest[2]."
3. *On the previous heat of the living surface.* Thus, a substance having a temperature of 60° F. will feel warm to the hand or other living part previously exposed to a temperature of 32° F., but cold to a part which immediately before was exposed to a heat of 96° F. or 98° F.
4. *On the frequency of renewal of the cooling agent.* Thus, the air feels much colder in

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[1] De Candolle, *Physiologie Végétale,* t. iii. p. 1117, Paris, 1832.

[2] Arnott's *Elements of Physics,* vol. ii. part 1. p. 25, Lond. 1829.

blowing or windy weather than in a calm and still condition of the atmosphere, although the actual temperature, as determined by the thermometer, may, in the two cases, be the same.

The sensation of cold is soon followed by a reduction of temperature, and a diminution of volume of the part. This last effect is partly physical, partly vital. Of course the solids and fluids of the body, in common with inorganised substances, must have their bulk reduced when their temperature is diminished; but a living part lessens in size from a vital manifestation—viz. the contraction of the living tissues. This contraction, or astriction, is especially manifested in the skin when exposed to a cooling influence. The cutaneous tissue becomes dry and shrivelled, while the bulbs of the hairs become elevated and manifested; constituting the state called goose-skin (*cutis anserina*). The muscular tissues become rigid, or spasmodically contracted; and this effect extends by sympathy to other muscular parts beyond those to which the cold is applied. The blood-vessels, in common with all other living parts, suffer contraction; and the quantity of blood circulating in them is thereby lessened, while its motion is retarded. The secretions and exhalations are checked or stopped; partly as a consequence of the effect on the circulation of the part, partly by the contraction of the secreting and exhaling organs. If the cold be excessive, or its action prolonged, the part, after suffering more or less uneasiness, loses its sensibility. This state of torpefaction or benumbing, when fully established, is denominated *frost-bite*, and, unless speedily relieved, is followed by the death of the part.

"I perceived one day on a journey," says Beaupré[1], "that two officers, prisoners of war, and my companions in misfortune, had the points of their noses of a horn white, the colour of old wax. I warned them, and frictions with snow were sufficient to remove this first stage of congelation, which they had not suspected. But what appeared to them very singular was, that, while I gave them advice, I myself needed the same—my nose was in the same condition; *sibi non carere et aliis consilium dare.* From that moment we were on the alert; we kept on our guard; and, that we might not fall victims to a security alike fatal and involuntary, each begged his neighbour, on terms of reciprocal service, to watch over his nose and ears."

"After entire cessation of pain, the part remains cold and insensible; sometimes phlyctenæ arise; sometimes the change of colour in the skin, which is livid and blackish, evinces from the commencement that there is mortification[2]."

If the cold be either moderate or only temporarily applied, reaction is readily induced. The disagreeable feeling of cold is succeeded by an agreeable sensation of warmth; the natural temperature returns, relaxation takes place, and the parts acquire their usual volume, colour, and sensibility. When the cold to which the part has been exposed is excessive, and the heat subsequently employed to excite reaction be too suddenly applied, inflammation and even gangrene ensue.

Pernio, or *chilblain*, is an inflammatory disease caused by cold.

That gangrene and death readily result from the sudden application of warmth to a frozen part, was known to Hippocrates[3], who states that a man having had his feet frozen, lost them by the application of warm water.

The true method of recovering frost-bitten parts consists in very gradually restoring their natural temperature by the use, first, of snow or ice frictions, then of cold water, and subsequently of luke-warm water.

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[1] *Treatise on the Effects and Properties of Cold*, translated by Dr. Clendinning, p. 132, Edinb. 1826.

[2] Ibid.

[3] *De Usu Liquidorum*, p. 425, ed. Fœsii.

β. *Effects of cold applied to the whole body.*—Temporary exposure to moderately cold air (from 30° to 45° F.) is agreeable, and, by the reaction which it establishes, exciting to the young and the vigorous. The coldness of surface and diminished capillary circulation, which it at first occasions, are soon followed by reaction, especially if exercise be conjoined. A more intense or a longer continued cold causes shivering, goose-skin, determination of blood to internal organs, coldness of surface, and a kind of spasmodic rigidity. These effects are much more severely experienced by the old, the debilitated, and the paralytic.

When the degree of cold is excessive, or its application too prolonged, it causes torpor, irresistible tendency to sleep, a kind of apoplectic condition, asphyxia, and death[1].

The diseases produced by cold are numerous[2]. Chilblains and frost-bites have been already referred to. Pulmonary affections are by far the most common of the internal maladies induced by cold. Scrofula is a disease of cold and moist climates. Rheumatism is another malady brought on by cold and moisture conjoined. Apoplexy and paralysis, especially in the aged, are occasioned by cold[3]. In addition to the diseases now mentioned, there are many others the progress of which is more or less promoted by cold.

On examining the bodies of persons killed by cold, congestion of the cerebral vessels, and effusion into the ventricles of the brain[4], have always been found.

USES.—We employ cold for the purpose of obtaining its primary, or its secondary effects[5].

a. Uses of the Primary Effects of Cold.—The primary action of cold is that of a depressing and sedative agent. When we use it therapeutically, we employ a more intense degree of cold, or continue its application for a longer period, than when we resort to cold for its secondary effects.

As a remedial agent, the primary effect of cold serves several important purposes, of which the following are illustrations:—

1. To lessen vascular and nervous excitement, and preternatural heat.

a. To lessen preternatural heat. *Examples.*—Cool air and cold sponging in ardent fever; cold lotions in headache with augmented heat of head.

b. To reduce vascular action. *Examples.*—Cold lotions or the ice-cap to the head in phrenitis; cold washes to inflamed parts. Cold applications are "with greater propriety employed before inflammatory action is fairly established; and they act by constringing the superficial vessels, with which those more deeply seated sympathise to a certain extent; but warm fomentations are more pleasant and useful when inflammation has really taken place[6]."

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[1] A remarkable and well-known instance of the strong tendency to sleep induced by cold occurred in one of Captain Cook's voyages (Hawkesworth's *Account of the Voyages in the Southern Hemisphere*, vol. ii. p. 46, Lond. 1773).—In both ancient and modern times military expeditions have furnished dreadful and notorious illustrations of the disastrous effects of cold, combined with other influences, on the human frame; as in the case of the Greeks under the command of Xenophon (*Cyropædia*, lib. iv.), and twice under the command of Alexander the Great (Pratt's Translation of Quintus Curtius's *History of Alexander the Great*, vol. ii. pp. 157 and 233, revised edit. 1821); of the Swedes, in 1719 (*Hist. Register* for 1719, vol. iv. pp. 308—310); of the French in 1742 (Beaupré, *op. cit.* p. 96), and in 1812 (Count Segur's *History of the Expedition to Russia undertaken by the Emperor Napoleon in* 1812, Lond. 1825; Beaupré, *op. supra cit* p. 93; Sir Henry Halford, *Lond. Med. Gaz.* vol. xix. p. 903); and of the British in Affghanistan in 1841-2 (Eyre, *Military Operations at Cabul*, Lond. 1843).

[2] See Dr. Clendinning, in the *Lond. Med. and Phys. Journ.* for June, July, and Sept. 1832.

[3] *Dict. of Pract. Medicine*, art. *Cold*, by J. Copland, M.D.

[4] Kellie, *Trans. of the Medico-Chirurgical Society of Edinburgh*, vol. i. p. 84.

[5] Gallot, *Diss. Inaug. De Frigoris Usu Therapeutico*, Berol. 1838.

[6] Liston, *Elements of Surgery*, p. 20, 2d edit. 1840.

c. To lessen nervous excitement, especially when combined with increased vascular action. *Examples.*—The ice-cap to relieve the low maniacal delirium of typhus fever; and the shower-bath, cold affusion, and the douche, in paroxysms of excitement in cases of insanity.

2. To constringe living tissues, to promote the coagulation of the blood, and to lessen the volume of parts.

a. To check hemorrhage. *Examples.*—Cool air, cold water, and ice to stop bleeding from numerous small vessels. In these cases the cold acts by causing contraction of the wounded extremities of the vessels, and by promoting the coagulation of the blood.

b. To promote the spontaneous cure of aneurism. *Example.*—Iced water and pounded ice to aneurismal tumors. Cold is employed, in these cases, with the view of restoring the elasticity of the arterial coats, and of promoting the coagulation of the blood within the aneurismal sac.

c. To promote the reduction of strangulated herniæ. *Example.*—Cold produced by the evaporation of ether applied to the hernial tumor; or the continued application of the ice poultice (pounded ice, or a freezing mixture, contained in a bladder,) to the part. Cold is used, in these cases, with the view of lessening the volume of the hernial tumor, which it may effect partly by constringing the living tissues, partly by causing a physical diminution of bulk of the contents of the hernial sac; but its efficacy is deserving of little faith.

3. To alleviate pain.

In slight burns or scalds, immediate relief from pain is obtained by plunging the part in cold water. Cardialgia is sometimes relieved by the internal use of ice or ice-cold water.

β. Uses of the Secondary Effects of Cold.—The secondary effects (commonly termed *reaction*) of cold are the opposite of the primary effects. When we desire to obtain them for therapeutical purposes, we employ cold of less intensity, or for a shorter period, than when we wish to procure the primary effects. Moreover, mechanical concussion is frequently conjoined, as in the shower-bath, the douche-bath, and cold affusion.

They are employed for several purposes, of which the following are illustrations:—

1. To strengthen and give tone to the system.

Examples.—The shower-bath and cold plunge-bath are used as ordinary hygienic agents to promote health and strength.

2. To make a sudden and powerful impression on the system.

a. To interrupt the progress of fever. *Example.*—Cold affusion has, in some cases, cut short fever at once; a disposition to sleep and sweating has ensued, and the patient has awoke almost free from disease.

b. To act on the excito-motory system. *Examples.*—Cool air, aspersion of cold water, and cold affusion in syncope, spasmodic closure of the glottis, hysteria, epilepsy, poisoning by hydrocyanic acid, opium, &c. Cold, in these cases, excites a sudden act of inspiration. "The influence of cold water dashed on the face, and the influence of the diffused contact of the cold bath, in exciting sudden sobbing acts of inspiration, are well known[1]."

3. To recal the vital properties to frost-bitten parts.

In the treatment of frost-bite, the object to be obtained is the very gradual restoration of the part to its normal state by the use, in the first instance, of the lowest degree of warmth, and, subsequently, of gradually augmented warmth.

4. To effect local excitation.

Examples.—Local douches or pumping in old rheumatic and paralytic affections, stiff joints, &c.

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[1] Dr. Marshall Hall, *On the Diseases and Derangements of the Nervous System*, p. 114, Lond. 1841.

CAUTIONS.—In the use of ice, ice-cold water, and freezing mixtures, some caution must be exercised, lest the cooling effect be carried too far. Nurses frequently err, from ignorance, on this point. The head and other parts of the body are frequently cooled down below the healthy standard, and, in some cases, the death and sloughing of the integuments are thereby produced.

In persons disposed to apoplexy, and in patients affected with maladies of the heart or lungs, cold bathing, especially in those unaccustomed to it, or in those whose circulation is feeble, is by no means devoid of danger.

METHODS OF COOLING THE BODY.—There are two methods of lowering the temperature of the body:—

1. By diminishing the amount of animal heat generated in the system; as by starvation, inactivity, loss of blood, and, perhaps, by the medicinal substances termed sedatives and refrigerants.
2. By the abstraction of heat from the body.

Of these two methods the latter is the special object of our present inquiries, and requires further examination.

The abstraction of heat from the body may be effected in three ways:—

1. By promoting the radiation of heat from the surface of the body.
2. By promoting evaporation from the surface of the body.
3. By conduction, or the contact of cold substances.

1. COLD BY RADIATION.

Heat radiates from all bodies, but unequally so: the hotter body, *cæteris paribus*, evolves more heat by radiation than the colder one. Hence, by exposure to cool air, the naked body is cooled partly by radiation, partly by the contact of the particles of cold air with the cutaneous surface. Clothing acts as a screen, and checks radiation and the contact of cold air.

On many occasions we avail ourselves of these circumstances, and use radiation as a means of cooling the living surface. Thus hemorrhage is frequently checked by exposing the bleeding surface to the cold air; and cerebral vascular excitement is lessened by uncovering or shaving the head.

2. COLD BY EVAPORATION.

The conversion of a liquid into a vapour is attended with the loss of heat. Hence if, at the surface of the body, evaporation be effected, cold is produced. The use of etherial, alcoholic, and aqueous evaporating lotions, to relieve local irritation and superficial inflammation, is so familiar to every one, as scarcely to require notice. Circumstances which promote evaporation augment the intensity of the cold. Thus fanning or blowing the part increases the cold by effecting a more rapid evaporation of the lotion. The application of these liquids should be effected by means of a single layer of thin muslin or linen, and not by a compress. A most intense degree of cold is produced by dropping ether on the part, and effecting rapid evaporation by blowing. Evaporating lotions are applied to the head with great relief in cephalalgia, phrenitis, fever with disorder of the cerebral faculties, and poisoning by opium. In the treatment of traumatic ophthalmia, as well as of the incipient stage of inflammation of the outer tunics of the eye, cold lotions are useful; but in internal ophthalmia they are injurious.

3. COLD BY CONDUCTION.

Cold substances placed in contact with the body cool it by conducting away its heat. Those which are employed for this purpose are *cold air*, *cold liquids*, and *cold solids*.

a. *Cold Air.*

In febrile diseases, accompanied with preternatural heat, exposure to pure and moderately cool air (from 50° to 60° F.) lowers the temperature of the body, and reduces excessive vascular action.

b. *Cold Liquids.*

α. Cold Liquids used externally.

1. THE COLD BATH.—The temperature of this ranges from 33° to about 75° F.: when below 50° F., the bath is considered very cold. Its primary effects constitute the *shock*,—its secondary effects, the *reaction* or *glow*.

The immediate effects of the cold bath are a sensation of cold (speedily followed by one of warmth), contraction of the cutaneous vessels, paleness of the skin, diminution of perspiration, and reduction of the volume of the body. Shivering, and, as the water rises to the chest, a kind of convulsive sobbing, are also experienced. Continued immersion renders the pulse small, and, ultimately, imperceptible, and the respiration difficult and irregular; a feeling of inactivity succeeds; the joints become rigid and inflexible; pain in the head, drowsiness, and cramps, come on; the temperature of the body falls rapidly; and faintness, followed by death, ensues.

The contracted state of the superficial vessels produced by the cold and by the pressure of the water causes the blood to accumulate in the internal vessels. The palpitations arise from the efforts made by the heart to rid itself of the increased quantity of blood thrown on it; while the pulse continues small, because the arteries remain contracted. The internal veins becoming gorged, the functions of the brain necessarily suffer; and hence arise headache, drowsiness, cramps, and, in some cases, apoplexy. The difficult respiration depends on the accumulation of blood in the lungs. The contracted state of the superficial vessels accounts for the diminished perspiration; while the increased secretion of urine is referable to the blood being driven towards the internal organs.

If the immersion be only temporary, reaction quickly follows. The cutaneous circulation is speedily re-established; a glow is felt; perspiration comes on; the pulse becomes full and frequent; and the body feels invigorated.

The cold bath is employed with the view of obtaining the nervous impression or shock,—the refrigeration,—or the re-action or glow[1]; but principally for the latter purpose in cases where it is desirable to increase the tone and vigour of the body.

In weakly and debilitated subjects, the reaction or glow is imperfectly effected, and in such the cold bath acts injuriously. In delicate persons (females especially), with feeble and languid circulation, cold extremities, and torpor of system, cold sea-bathing frequently aggravates all these symptoms[2]. Whenever cold bathing is followed, for several hours, by coldness of surface, blueness of lips, feeble pulse, reduction of strength, and headache, its use should be prohibited.

In diseases of the heart and lungs it is a dangerous remedy; as also in persons disposed to apoplexy, and who are unaccustomed to cold bathing.

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[1] *Cyclopædia of Practical Medicine*, art. *Bathing*, by Dr. J. Forbes.

[2] For some judicious remarks on this subject, consult Dr. Metcalfe's work entitled *Caloric; its Mechanical, Chemical, and Vital Agencies in the Phenomena of Nature*, 2 vols. 8vo. Lond. 1843.

It is a common opinion that immersion in cold water is dangerous when the body is heated by exercise, or other exertion; and hence it is customary with bathers to wait until they become cool. Dr. Currie[1] has strongly combated both the opinion and the practice: the first, he says, is erroneous, the second injurious.

The Cool Bath (whose temperature is from 60° to about 75°) is commonly used as a luxury, and for cleanliness.

2. COLD AFFUSION (*perfusio; κατάχυσις*).—Affusion was employed, as a hygienic agent and luxury, by the Greeks and Orientals at a very early period. Homer[2] makes some allusions to it; Hippocrates[3] used it in medicine; and Celsus[4] recommends it in some affections of the head. The last-mentioned writer also states, that Cleophantus (a physician who lived about 300 years before Christ) employed hot affusion in intermittents[5].

The affusion on the head is thus effected:—The water is to be poured on the head (inclined over a pan or tub), by means of an ewer or pitcher, from a height of two or three feet. If the patient be confined to his couch, the head should be inclined over the side of the bed. In children, it is sufficient to squeeze a large sponge (previously soaked in water) at some height above the head, as recommended by Dr. Copland[6]. When the object is to apply affusion to the whole body, the patient is placed in a large tub or pan (*e. g.* a bathing tub or washing pan), and then an attendant, standing on a chair, may readily effect it. The time that the affusion should be continued varies, according to circumstances, from a quarter of a minute to two or three minutes; but in some cases it has been employed for twenty minutes. After the affusion the body should be carefully wiped dry, the patient wrapped up warm, and placed in bed.

The effects of affusion depend partly on the temperature of the liquid, and partly also on the sudden and violent shock given to the system by the mechanical impulse; hence the reason why the effects vary according to the height from which the water is poured.

When water whose temperature is between 32° and 60° F. is used, we denominate the affusion *cold.* To a certain extent the effect of cold affusion is analogous to that of the cold bath, but modified by two circumstances, namely, the short period during which the cold is applied, and the mechanical influence of the stream: hence, its primary effects are very transient, and reaction speedily follows. By a long continuance of affusion, however, the heat of the body is considerably reduced, and the same diminution of vital action occurs as when the cold bath is employed. "When," says Dr. Copland, "the stream of water is considerable, and falls from some height upon the head, the effect on the nervous system is often very remarkable, and approaches more nearly than any other phenomenon with which I am acquainted to electro-motive or galvanic agency."

Cold affusion is used principally in those cases where it is considered desirable to make a powerful and sudden impression on the system; as in continued, intermittent, and eruptive fevers. In *fever* it may be used with safety, according to Dr. Currie[1] and others, "when there is no sense of chilliness present, when the heat of the surface is steadily above what is natural, and when there is no general or profuse perspiration." It is inadmissible during either the cold or the sweating stage of fever, as also in the hot stage, when the heat is not greater than ordinary. In some instances it seems to act by the shock it communicates to the system; for the effect is almost immediate, the disease being at once cut short. The patient has fallen asleep immediately afterwards, profuse perspiration has succeeded, and from that time recovery commenced. This plan of extinguishing a fever, however, frequently fails; and, in that event, it may place the patient in a worse condition than before: hence it is not often adopted.

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[1] *Medical Reports on the Effects of Water, cold and warm, as a Remedy in Fever and other Diseases*, vol. i. p. 112.

[2] *Odyssey*, x. 362.

[3] *Aphorismi*, sect. v. aph. 21; and sect. vii. aph. 42.

[4] Lib. i. cap. 4.

[5] Ibid. lib. iii. cap. 14.

[6] *London Medical Gazette*, vol. x.

In *eruptive fevers* it has been applied during the fever which precedes the eruption, as also after this has been established; it has been used in both scarlet fever and small-pox, and even in measles; but its employment in the latter disease is objectionable, on account of the tendency to pulmonary inflammation, in which affection cold affusion is prejudicial.

Cold affusion has been used in *croup*, principally with the view of removing the spasm of the glottis, which endangers the life of the patient.

Cold affusion is used with advantage in numerous other diseases: as in *poisoning* by hydrocyanic acid, alcohol, opium, belladonna, &c.; in *asphyxia* caused by the inhalation of carbonic acid, the fumes of burning charcoal, sulphuretted hydrogen, &c.; in *hysteria* and *epilepsy*; in *puerperal convulsions*; in *mania*; as also in *tetanus*. In *malignant cholera* it sometimes proved valuable[2]; principally, however, in mild cases. In severe attacks the power of reaction was insufficient. In the latter stages of inflammatory and other *brain affections* of children it is often serviceable.

Cool and tepid affusion are employed as substitutes for cold affusion where dread is entertained of the effect of the latter. They are safer, though less powerful agents.

3. THE SHOWER-BATH (*impluvium*).—The shower-bath is very similar in its effects to, but milder than affusion, and is frequently employed as a hygienic agent to promote the tone and vigour of the body. In insanity it is used with the greatest benefit to allay mental excitement. In violent cases, "the application of the shower-bath, the patient being up to the middle in warm water, seldom fails to subdue the paroxysms[3]." The period during which it should be continued is a circumstance of some moment. Dr. Conolly observes that it "should be suspended when the patient appears overcome, and instantly renewed when symptoms of violence recur. A strong shower continued even for a minute has sometimes considerable effect;" and it should never be "many minutes prolonged without careful observation of the patient's state. After four or five applications of this kind, the patient becomes entirely subdued, and should then be taken out of the bath, rapidly dried, warmly covered up, and put into bed, with every possible demonstration of kind attention. Calmness and sleep are the usual results; and more permanent effects frequently follow. A bath of this kind appears to produce a moral as well as a physical impression; being succeeded, in recent cases, by tranquillity for a

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[1] *Op. supra cit.*

[2] *Lond. Med. Gaz.* vol. ix. p. 452, 502, and 505.

[3] Dr. Conolly's *Report*, before quoted, p. 66.

few days, and in chronic cases by quietness and improved behaviour for many weeks, and sometimes even for months."

An extemporaneous shower-bath, produced by the aid of a cullender, may be used to allay the violent delirium of fever; and is rendered more beneficial if the patient can be persuaded to sit in a semicupium of warm water[1].

4. THE DOUCHE (*duccia*).—The term *douche* is applied to a stream of water directed to, or made to fall on, some part of the body. Its effect depends in part on the mechanical action or percussion, and in part on the temperature, of the liquid. A column of water twelve feet high, made to fall perpendicularly on the top of the head, excites such a painful sensation, that, it is said, the most furious maniacs, who have once tried it, may sometimes be awed merely by the threat of its application; and hence one of its uses in madness, as a means of controlling the unfortunate patient. "At this moment a controversy is proceeding among certain French physicians concerning the application of the douche; which some are disposed to use as a specific against delusive notions. The patient is kept under the douche until he entirely recants. The principle is extremely doubtful; and it should be remembered of every severe application, that lunatics are seldom able to make their real sufferings distinctly known. M. Esquirol subjected himself to the douche; and he describes the sensation as very painful, resembling the continued breaking of a column of ice on the head, followed by a feeling of stupefaction which lasted an hour afterwards[2]."

The douche is one of the remedies employed by hydropathists.

It is a powerful and dangerous stimulant, and requires great caution in its use and application.

Topical douches are applicable in some cases of local disease requiring a powerful stimulus; as old chronic affections of the joints, whether rheumatic, gouty, or otherwise[3]; paralytic affections; sciatica; old glandular swellings; chronic headache; deafness, &c. Dr. Butzke[4], has recently employed it with good effect in old ulcers of the feet.

The eye-douche has been employed as a hygienic agent. Jungken regards it as an effective stimulant for promoting the restoration of convalescent eyes, and which may be substituted for eye-waters and spirit-washes. Beer contrived an apparatus for effecting it. It consisted of a double tin vessel; the outer vessel containing ice, to cool the water contained in the inner one. From the inner vessel descended a narrow tin tube of about four or five feet long, and terminating in a fine jet turned upwards, from which, when required, could be obtained a slender stream of water, which was regulated by a stop-cock. Schmalz, Mauthner, and Bischoff, have effected various modifications of this apparatus. The simplest method consists of a tumbler filled with ice-cold water, into which dips the short leg of a glass syphon. The longer leg of the syphon should descend considerably below the bottom of the tumbler, and terminate in a small point curved upwards. Gräfe employed adaptation tubes of glass or brass, which were attached to the syphon by an india-rubber collar, and by means of which every requisite direction and force could be given to the jet of water.

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[1] Dr. Lendrick, *Lond. Med. Gaz.* vol. xxiv. p. 104.

[2] Dr. Conolly's *Report*, before cited, p. 68.

[3] See some observations of Lisfranc on the use of the douche in white swelling, in the *Lancet* for 1834-35, vol. ii. p. 337.

[4] *London Medical Gazette* for 1839-40, vol. i. p. 893.

The operation of *pumping* practised at Bath may be regarded as a kind of douche. The degree or extent of the application is determined by the number of times the handle of the pump is raised or depressed. From 20 to 200 strokes of the pump is the number generally directed to be taken at one time, which, however, may be increased or diminished according to the age, sex, strength, or other circumstances of the patient[1]. The water does not issue in gushes, but in a continuous stream.

5. WASHES.—Cold, cool, or tepid washing or sponging may be used in febrile diseases, with great advantage, in many cases where affusion is not admissible, or where timidity on the part of the patient or practitioner prevents the employment of the latter. Dr. Currie[2] remarks, that in all cases of fever where the burning heat of the palms of the hands and soles of the feet is present, this method of cooling them should be resorted to. A little vinegar is frequently mixed with the water, to make the effect more refreshing. Cold washing is also used to lessen the susceptibility of the skin, and diminish the liability to rheumatism and catarrh. On the same principle it is employed to check nocturnal emissions. Washing or sponging must be effected under precisely the same regulations as those already laid down for affusion.

Dr. Kinglake[3] recommended the application of cold water to parts affected with gout, but the practice is somewhat hazardous. One method of treating burns is by the application of cold water to the injured part. In modern times, Sir James Earle[4] was the great advocate for this plan, which proves more successful in scalds and slight burns. The burnt part should be covered with rags, and kept constantly wetted with water, in which ice is placed from time to time; "care being taken never to remove the rags from the burnt surface[5]."

If the cold fluid be continually renewed, the practice has been called *irrigation*[6]. It is effected either by allowing cold water to drop on the affected part, from a stopcock inserted in the side of a bucket of water, or by conducting a stream of water from a vessel by means of a strip of cloth, on the principle of a syphon.

β. Cold Liquids used internally.

1. COLD DRINKS.—Hippocrates[7], Celsus[8], and other ancient writers, employed cold water as a drink in ardent fever. In modern times, also, it has been extensively used in the same malady. Dr. Hancocke[9] called it the *febrifugum magnum*. Its employment, however, has not been limited to fever. From its supposed great efficacy in gouty complaints, Heyden[10] termed it the *arthritifugum magnum*.

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[1] *A Practical Dissertation on the Medicinal Effects of the Bath Waters*, by W. Falconer, M.D. 1790.

[2] *Reports*, 4th edit. vol. i. p. 72.

[3] *A Dissertation on the Gout*, Lond. 1804; *Additional Cases of Gout*, Lond. 1807.

[4] *An Essay on the Means of lessening the Effects of Fire on the Human Body*, Lond. 1799.

[5] *Two Lectures on the Primary and Secondary Treatment of Burns*, by H. Earle, Lond. 1832.

[6] Macartney, *Treatise on Inflammation*, p. 158, Lond. 1838.

[7] *De Usu Liquidorum.*

[8] Lib. iii. cap. 7.

[9] *Febrifugum Magnum, or Common Water the best Cure for Fevers, and probably for the Plague*, 5th edit. Lond. 1723.

[10] *Arthritifugum Magnum, a Physical Discourse on the Wonderful Virtues of Cold Water*, Lond. 1724.

We are indebted to Dr. Currie for the examination of the circumstances under which the internal employment of cold water in fever is proper. According to him, it is inadmissible during the cold or sweating stage, but is both safe and advantageous when the skin is dry and burning: in other words, the regulations for it are precisely the same as for cold affusion. When exhibited under proper circumstances, cold water operates as a real refrigerant, reducing preternatural heat, lowering the pulse, and disposing to sweating. Occasionally, however, serious and even fatal consequences have resulted from the employment of large quantities of it by persons who have been rendered warm by exercise or fatigue.

Besides fever, there are several other affections, in which cold water is a useful remedy. For example: to facilitate recovery from epilepsy, hysteria, and fainting; and to alleviate gastric pain and spasm. Large draughts of it have sometimes caused the expulsion of intestinal worms (*Tænia* and *Ascaris vermicularis*).

2. COLD INJECTIONS.—*a.* Cold water is thrown into the *rectum* to check hemorrhage, to expel worms, to allay local pain, to rouse the patient in poisoning by opium; and to diminish vascular action in enteritis.

b. Dr. A. T. Thomson[1] speaks very favourably of the effects of cold water introduced into the *vagina*, by means of the stomach-pump, in uterine hemorrhage.

The COLD WATER-CURE, or HYDROPATHY, though not yet admitted by the medical profession among the legitimate means which may be beneficially employed in the treatment of diseases, undoubtedly includes powerful therapeutic agents, which, in the hands of the educated and honourable practitioner, might be most beneficially resorted to as remedial agents. It does not confine itself to the use of *cold water* only, but includes *dry sweating*, *diet*, *exercise*, and *regulated clothing*. The cold water is employed both internally and externally: *internally* in the form of potions, gargles, lavements, and injections into the ears, urethra, and vagina; *externally* by baths, ablutions, wet linen sheets, and wet compresses. The baths are both general and local: the former include full baths (portable, plunging, river, and wave baths), half baths, shower-baths, douches (including the sturz-bath, a douche on a large scale), and drop-baths; the local baths comprehend the sitz-bath (sitting bath) either in still or flowing water, the foot-bath, the hand-bath, the head-bath, the ear-bath, the eye-bath, &c.—To works professedly devoted to this subject I must refer the reader who may be desirous of information respecting it.

c. *Cold Solids: Ice and Snow.*

The temperature of these agents does not exceed 32° F. They are employed both internally and externally, to obtain sometimes the primary, at other times the secondary effects of cold.

1. EXTERNAL USE.—*a. Of the Primary Effects.*—Ice is used to check hemorrhage, more especially when the bleeding vessel cannot be easily got at and tied; as after operations about the rectum, more especially for piles and fistula. It is applied to the chest in dangerous hemoptysis, and to the abdomen in violent floodings. In some of these cases, especially in uterine hemorrhage, more benefit is obtained by pouring cold water from a height (*cold affusion* or *douche*) than by the use of ice.

A bladder containing pounded ice (*ice poultice*) has been applied to hernial tumors to diminish their size and facilitate their reduction; but notwithstanding that the practice has the sanction and recommendation of Sir Astley Cooper[1], it is, I believe, rarely followed, not having been found successful; while, if too long continued, it may cause gangrene. In this, as well as in other cases, where ice or snow cannot be procured, *a freezing mixture* may be substituted. For this purpose, five ounces of sal ammoniac, five ounces of nitre, and a pint of water, are to be placed in a bladder, and applied to the part. Ice has also been applied in prolapsus of the rectum or vagina, when inflammation has come on, which threatens to terminate in mortification.

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[1] *Elements of Materia Medica and Therapeutics*, vol. ii. p. 78, Lond. 1833.

The *ice-cap* (*i. e.* a bladder containing pounded ice) is applied to the head with great benefit in inflammation of the brain; in fever, where there is great cerebral excitement, with a hot dry skin; and in acute hydrocephalus. In apoplexy, likewise, it might be useful; as also in delirium tremens, and in mania with great mental excitement. In the retention of urine, to which old persons are liable, ice-cold water applied to the hypogastrium is sometimes very effective in causing the evacuation of this secretion.

b. Of the Secondary Effects.—Friction with ice or snow is employed to produce the secondary effects of cold in diminished sensibility of the skin, and in the rheumatism or gout of old and enfeebled persons; but its most common use is as an application to frost-bitten parts. The feet, hands, tip of the nose, and pinnæ of the ears, are the organs most frequently attacked. In order to guard against mortification, and other ill effects arising from a too rapid change of temperature, the vital properties must be slowly and gradually recalled. In order to effect this, the frost-bitten part should be rubbed with snow or pounded ice, or bathed in ice-cold water, very gradually raising the temperature of the applications until the part acquires its natural heat.

2. INTERNAL USE.—Ice, or ice-cold water, is swallowed for the purpose of obtaining either the primary or the secondary effects of cold. Thus, it is taken to cause contraction of the gastric vessels, and thereby to check or stop hemorrhage from the mucous membrane of the stomach. It has also been found beneficial in nasal, bronchial, and uterine hemorrhage. In the latter cases, the constriction of the bleeding vessels must be effected through the sympathetic relations which exist between the stomach and other organs. Ice is also employed to relieve cardialgia, vomiting, and spasmodic pain of the stomach. In the latter stage of typhus fever its internal use is sometimes beneficial.

4. ELECTRICITAS.—ELECTRICITY.

GENERAL REMARKS.—The agent or force denominated electricity (from *ἤλεκτρον, amber*) appears to exist in all terrestrial bodies; either in a *passive* and *quiescent* condition, or in an *active* and *free* one. The latter state may be induced by a variety of circumstances, which are denominated *modes of electrical excitement*, or *sources of electricity*; and the bodies in which this condition of electrical activity is made manifest are said to be *electrified*.

Active or *free electricity* exists either in a state of rest and equilibrium, when it is called *statical*, or in that of motion or progressive action, when it is termed *dynamical*. Its activity is manifested by the production of various phenomena, denominated its *effects*, and which are of six kinds; namely, *mechanical*, *luminous*, *calorific*, *chemical*, *magnetic*, and *physiological*.

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[1] *The Anatomy and Surgical Treatment of Inguinal and Congenital Hernia*, p. 25, Lond. 1804.

The phenomena presented by electricity, obtained from different sources, differ "not in their character, but only in degree; and, in that respect, vary in proportion to the variable circumstances of *quantity* and *intensity*[1]."

"The term *quantity*, in electricity," says Dr. Faraday, "is, perhaps, sufficiently definite as to sense; the term *intensity* is more difficult to define strictly." It is commonly used to indicate the ability or power which electricity possesses of overcoming resistance to its progress, and which varies in degree in different cases.

The voltaic battery yields a large quantity of electricity of low intensity, and which possesses great chemical and but little attractive and repulsive powers; whereas the common electrical machine gives a small quantity of electricity of high intensity, and whose chemical powers are very feeble, but whose attractive and repulsive influence is very great. The former source, therefore, is said to yield *electricity of quantity*; the latter, *electricity of intensity*.

The relative *quantities* of electricity evolved by the ordinary electrical machine and the voltaic battery have been ascertained by Dr. Faraday[2] to be as follows:—A voltaic battery, consisting of "two wires, one of platina and one of zinc, each one-eighteenth of an inch in diameter, placed five-sixteenths of an inch apart, and immersed to the depth of five-eighths of an inch in acid, consisting of one drop of oil of vitriol and four ounces of distilled water of about 60° Fah., and connected at the other extremities by a copper wire eighteen feet long, and one-eighteenth of an inch in thickness, yielded as much electricity, in little more than three seconds of time, as a Leyden battery charged by thirty turns of a very large and powerful plate machine [fifty inches in diameter] in full action." And the same authority further observes, that 800,000 such charges of this Leyden battery "would be necessary to supply electricity sufficient to decompose a single grain of water."

The relative degrees of *intensity* of the electricity obtained from the common electric machine and from the voltaic battery have not been accurately measured. The following illustrations, however, will give some idea of their enormous difference:—"When in good excitation," says Dr. Faraday[3], "one revolution of the plate [machine above alluded to] will give ten or twelve sparks from the conductors, each an inch in length. Sparks or flashes, from ten to fourteen inches in length, may be easily drawn from the conductors." It is obvious, therefore, that the intensity of the electricity thus obtained is very great. But that of voltaic electricity, though varying according to the chemical character of the elements used and the energy or intensity of the affinities[4], is always much more feeble. Mr. Gassiot[5] found that the electricity produced by 320 series of Daniell's constant battery affected the gold-leaf electrometer, but did not possess sufficient intensity to pass through $\frac{1}{5000}$th of an inch of air. With a water-battery of 3520 pairs, the sparks were only $\frac{1}{50}$th of an inch long[6]. Lastly, with 100 series of Grove's nitric acid battery, carefully insulated, the terminals consisting of copper disks six inches in diameter, the sparks obtained were only $\frac{1}{1000}$th of an inch in length[7].

The action or effect called the *discharge* may be effected in four modes[8]: by conduction, by convection, by disruption, and by electrolysis.

The discharge of electricity through the animal body, like that through water and acidulated and saline solutions, is effected by electrolysis.

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[1] *Experimental Researches in Electricity*, by M. Faraday, Lond. 1839, 8vo. p. 102; and *Phil. Trans.* 1833.

[2] *Op. cit.* pp. 102—7, and pp. 252—53.

[3] *Op. cit.* p. 84.

[4] Faraday, *Phil. Trans.* 1834, 9th Series of Researches, § 905—909.

[5] *Phil. Trans.* 1840.

[6] *Ibid.* 1844.

[7] Meeting of the British Association, 1846.

[8] Faraday, *Phil. Trans.* 1838, 12th Series of Researches.

In the electrolytic discharge, the *ions*, or substances which are evolved or set free by the electro-chemical decomposition, appear only at the electrodes or poles, these being "the limiting surfaces of the decomposing substance, and, except at them, every particle finds other particles, having a contrary tendency, with which it can combine[1]."

In every mode of effecting electrical excitement there are two opposite or antagonist electricities set free: the one, called *positive* or *vitreous*; the other, *negative* or *resinous*.

The physical and chemical phenomena produced by an electric discharge vary somewhat according as it takes place from a positive or negative surface[2]. The physiological effects appear to be the same; though formerly positive electricity was supposed to be stimulant, while negative electricity was thought to be sedative[3].

PHYSIOLOGICAL EFFECTS.—*a. On Vegetables.*—No conclusive evidence has hitherto been adduced demonstrative of the influence of electricity in promoting vegetation[4].

b. On Man and other Animals.—Electricity is distinguished from other physical agents by its faculty of affecting all our senses; whereas "light excites no organs but those of vision. Heat acts only on our feeling; whilst magnetism exerts upon our frames no perceptible influence whatever[5]."

It will be convenient to consider the effects first of statical, and afterwards of dynamical, electricity.

1. *Effects of Statical Electricity on Man and other Animals.*—No perceptible influence is exercised by statical electricity over the animal functions. In clear and serene states of the weather, the atmosphere is usually charged with positive electricity, which, by induction, renders the surface of the earth, and all living beings thereon, negative; while, in damp and wet weather, the reverse states usually exist; the atmosphere being negative, and the surface of the earth positive. We are unable, however, by our feelings to detect these opposite electrical conditions of the atmosphere, or to ascribe to them any peculiar influence on the system.

When we place a patient in what is called the *electric bath*, that is, on the insulating stool or chair, and in connection with the prime conductor of a common electrical machine, the whole surface of the body becomes charged with positive electricity, while the atmosphere surrounding it is rendered negative; but no constant and certain physiological effect is observed therefrom. In some cases, it is said the pulse is quickened; in others, unaltered; while, in a third class of cases, it becomes reduced in frequency at the end of ten or fifteen minutes[6]. But these phenomena, as well as the copious perspiration, which has also been ascribed to the electric bath, are referable rather to the excited imagination, fear, or other feelings of the patient, than to the direct influence of electricity on the body.

2. *Effects of Dynamical Electricity on Man and other Animals.*—The

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[1] Faraday, *Phil. Trans.* 1833, 5th Series of Researches, § 535.

[2] *Ibid.* 1838, 12th and 13th Series of Researches; Walker, *Account of Experiments with a Constant Battery*, in the *Transactions of the London Electrical Society*, 1838.

[3] Apjohn, in *Cyclopædia of Practical Medicine*, vol. i. art. *Electricity*.

[4] See an interesting paper by Mr. Edward Solly, *On the Influence of Electricity on Vegetables*, in the *Journal of the Horticultural Society*, vol. i. 1845. Also, *Further Observations*, in the same Journal, 1847.

[5] Peschel's *Elements of Physics*, vol. ii. p. 1, 1846.

[6] See Mr. Smith's experiments, in Dr. Hodgkin's Translation of Edwards' work, *On the Influence of Physical Agents on Life*, p. 335, Lond. 1832

progressive action or motion of electricity, usually denominated the *electric current*, produces remarkable and powerful effects on the animal system: these we may conveniently arrange under four heads; viz. effects on the nervous system, effects on the muscles, effects on the secretory organs, and effects on the heart and blood-vessels.

a. Effects on the Nervous System.—According to Matteucci[1], the nerves are somewhat better conductors of electricity than the cerebral substance; but their conducting power is four times less than that of muscle. Todd and Bowman[2], however, could detect no appreciable difference in the conducting power of nerve and muscle.

But the nerves do not appear to be equally good conductors in all directions; at least, it appeared to Matteucci that the spinal nerves were better conductors in the centrifugal than in the centripetal direction[3].

aa. On the Nerves of Sensation.—The electric current acts like other stimulants on the nerves of sensation, and excites the special function of each nerve. Thus, when transmitted along the *nerves of touch*, it excites pain, the shock, and other disagreeable sensations; along the *optic nerve*, it causes the sensation of light; along the *gustatory nerve*, a remarkable taste; along the *auditory nerve*, sound[4]; and along the *olfactory nerve*, the sensation of smell[5].

The effect on the gustatory nerve is not referable to the action of the substances produced by the electrolysis of the salts of the saliva; for, *firstly*, the sensation may be excited by a current which is too feeble to decompose these salts; and, *secondly*, Volta experienced an acid taste from the influence of an electric current at the moment when his tongue was in contact with an alkaline solution.

ββ. On the Nerves of Motion.—When an electric current is transmitted along a nerve of motion, contraction of the muscles to which the nerve is distributed is produced.

MM. Longet and Matteucci[6] have made some very curious observations on the effects of the electric current on motor nerves. Immediately after the death of the animal, muscular contractions are induced both at the commencement and at the interruption or cessation of the current, whether it be direct or inverse. But some time after, or in what is called the second stage of the vitality of the nerve, the muscles are thrown into contraction only at the commencement of an inverse or centripetal current, and at the cessation of a direct or centrifugal current.

A current is said to be *direct* or *centrifugal* if it pass in the direction from the brain towards the distal extremities of the nerves. An *inverse* or *centripetal* current is one that passes in the opposite direction.

The susceptibility of motor nerves to the influence of the electric current may be destroyed by the action of narcotic poisons; by a sufficiently prolonged separation of the nerves from the central parts of the nervous system; by a ligature interposed between the parts of the nerve irritated and the muscles;

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[1] *Traité des Phénomènes Electro-Physiologique des Animaux*, p. 48, Paris, 1844.

[2] *Physiological Anatomy*, p. 243, 1845.

[3] *Traité*, p. 50.

[4] Volta, *Phil. Trans.* for 1800, p. 403.

[5] Müller's *Elements of Physiology*, by Baly, vol. i. p. 623, Lond. 1838.

[6] *Rapport entre le sens du Courant électrique et les Contractions musculaires dues à ce Courant*, (*Comptes rendus de l'Académie des Sciences du* 9 Sept. 1844).

and by continued excitation of the nerve[1]. But the muscular contractions caused by the commencement of the inverse current continue to be produced for a much longer time than those which arise from the cessation of the direct current.

γγ. On mixed Nerves.—By mixed nerves are meant, nerves which have a double root, and which, therefore, are both sensitive and motor. A current of electricity transmitted along a mixed nerve excites both sensation and muscular contraction.

MM. Longet and Matteucci[2] have observed a very remarkable difference in the effect of the electric current on the motor and mixed nerves. In the second stage of the vitality of the mixed nerves, the direct or centrifugal current excites contractions only at its commencement; while the inverse or centripetal current excites them only at its cessation. These phenomena are directly the reverse of those which occur in the case of the motor nerves before noticed.

In the following table, the different effects of centripetal and centrifugal currents are contrasted:—

EFFECTS OF ELECTRIC CURRENTS ON MOTOR AND MIXED NERVES.

NERVES.	EFFECTS OF CURRENTS.					
	Direct or Centrifugal Current.			*Inverse or Centripetal Current.*		
	Commencement.	Closed Circuit.	Cessation.	Commencement.	Closed Circuit.	Cessation.
1st *Period of Vitality.*						
Motor nerves	Muscular contractions.	No effect	Muscular contractions.	Muscular contractions.	No effect	Muscular contractions.
Mixed nerves ...	Strong contractions of superior and inferior muscles[3], and pain.	No effect	Contraction of superior and inferior muscles, and pain.	Contraction of superior and inferior muscles, and great pain.	No effect	Contractions of superior and inferior muscles, and pain.
2d *Period of Vitality.*						
Motor nerves	No effect......	No effect	Muscular contractions.	Muscular contractions excitable for a longer period.	No effect	No effect.
Mixed nerves ...	Contractions of the inferior muscles.	No effect	Contractions of superior muscles, and pain.	Contractions of superior muscles, and pain.	No effect	Contraction of inferior muscles.

δδ. On the Ganglionic or Sympathetic Nerves.—The ganglionic or sympathetic nerves are sensitive, and possess a motor though involuntary influence over the parts they supply: hence, therefore, a current of electricity transmitted along these nerves should, in conformity with its influence on the mixed nerves above noticed, excite both sensation and muscular contraction. Matteucci[1] confirms the statement of Humboldt and Müller[2], that the electric current applied to the cardiac and splanchnic nerves excited respectively contractions of the heart and the peristaltic movements of the intestines; but I am unacquainted with any experiments in which sensation was excited by the influence of electricity on the ganglionic nerves.

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[1] Matteucci, *Traité*, p. 214.

[2] Longet and Matteucci, *Rapport*.

[3] The terms *superior* and *inferior* refer to the point of excitation. The superior muscles are those supplied from nerves which come off above the point of excitation; the inferior muscles, on the contrary, are those supplied from nerves which come off below the point of excitation. Contractions of the superior muscles are *reflected movements*, and are due to the irritation of the nervous centre affected through the sensitive nerves.

Matteucci has observed some remarkable peculiarities in the action of the current on the ganglionic nerves. Instead of commencing immediately on the closure of the circuit, the contractions did not appear until some time subsequently, and they continued after the current had ceased. In these respects, however, electricity agrees with other stimulants in its action on these nerves. Matteucci was unable to recognise any well-marked difference between the effects, on the ganglionic nerves, of the direct or centrifugal current and those of the inverse or centripetal one.

The influence, on the secreting organs, of the electric current transmitted along the ganglionic nerves is an interesting object of inquiry, and one which requires examination. Krimer[3] states that, by division of the sympathetic nerve in the neck, the urine was rendered alkaline and albuminous; but, on the application of galvanism, its normal properties were restored.

εε. On the Nervous Centres.—Instantaneous death is produced by the passage of powerful charges of electricity through the brain. Rabbits and other small animals may be thus destroyed by the discharge from the electrical battery, or even from a large Leyden jar; and the death produced by lightning is a further illustration of the instantaneous and fatal effects of electricity on the nervous system.

When the charge is not sufficiently powerful to cause immediate death, the effects produced are analogous to those of concussion of the brain[4].

Mr. Singer[5] "once accidentally received a considerable charge from a battery through the head; the sensation was that of a violent but universal blow, followed by a transient loss of memory and indistinctness of vision, but no permanent injury ensued." The same authority observes that, if "the charge is passed through the spine, it produces a degree of incapacity in the lower extremities; so that if a person be standing at the time, he sometimes drops on his knees, or falls prostrate on the floor."

Some interesting experiments have been made by Matteucci[6], both alone and in conjunction with Longet[7], on the effects of the voltaic current on the nervous centres of animals. Neither muscular contractions nor apparent pain were produced when the current was transmitted through the cerebral hemispheres, or through the cerebellum, or through the pulp of the hemispheres either of the cerebrum or cerebellum. Neither were any contractions produced by the passage of the current through either the posterior columns or grey substance of the spinal cord. But both pain and muscular contractions were induced when the current acted on the corpora quadrigemina and crura cerebri; and the effect of both the direct and the inverse current on the anterior columns of the cord were the same as those produced on the motor nerves; that is, contractions were excited under the same circumstances. We may conclude, therefore, says Matteucci, that the electric current acts on the central parts of the nervous system like other stimulants whose action has been so well determined by M. Flourens.

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[1] *Traité*, p. 247.
[2] Müller's *Physiology*, by Baly, vol. i. pp. 191 and 663.
[3] *Ibid.* p. 470.
[4] *Lond. Med. Gazette*, xiv. 654.
[5] Singer, *Elements of Electricity*, p. 295, Lond. 1814.
[6] *Traité*, p. 242.
[7] *Rapport.*

2. *Effects on the Muscles.*—It has been ascertained by Matteucci, that a current of electricity causes the contraction of a muscle from which all visible nerves have been carefully removed; and that the contractions occur both at the commencement and cessation of the current, and are independent of its direction; and he infers from his experiments—

1st. That the property of contracting possessed by the living muscular fibre is inherent.

2dly. That the motor nerves, when irritated, produce contractions in the muscles to which they are distributed by acting on this inherent property of the muscle.

3dly. That the nerves may be temporarily deprived of this property by circumstances which I have before stated.

4thly. That the muscular fibre requires, for the continuance of its irritability, the simultaneous action of sensitive and organic nerves, and of blood, by which its nutrition is kept up.

When a current of electricity traverses simultaneously muscles and nerves, the contractions which ensue are principally due to the action of the current on the nerve: for, when the current is direct, the contractions occur at its commencement; whereas, when it is inverse, they occur at its cessation.

3. *Effects on the Secreting Organs.*—Although little is known with respect to the precise agency of the nerves in the act of secretion, yet we have abundant evidence to prove that they exercise some influence on this process; and, as the electric current excites the motor and sensitive nerves, it appears, *à priori*, probable that it may also excite the nerves distributed to the secreting organs. "The experiment instituted by the Baron A. von Humboldt on his own person is well known. Having applied two blisters to the region of the shoulders, he covered one of the blistered surfaces with a silver plate, and closed the circle by means of a conductor of zinc, when a painful burning was produced, and a change in the character of the discharge; from being bland and colourless, it became a red acrid fluid, which left livid red streaks on the parts of the back where it ran. M. Most likewise states that, having caused a galvanic current to pass through the parotid, by applying the positive pole to the situation of the gland for the space of ten minutes while he held the negative pole in his hand, an increased secretion of saliva, which was neither acid nor alkaline, took place[1]." Furthermore, Krimer reports that the division of the sympathetic nerve in the neck caused the urine to become alkaline and albuminous; but that the application of galvanism restored its normal properties[2].

Dr. Wilson Philip[3] divided the nervi vagi in a rabbit, and found, as he supposed, that the digestive process was stopped; and in another experiment he restored, as he tells us, the functions of these nerves by the voltaic influence. But subsequent experiments have shown that the division of the nervi vagi does not wholly stop the digestive process, and that electricity cannot restore it to its original state[4].

4. *Effects on the Heart and Blood-vessels.*—I have already stated that contractions of the heart may be induced by galvanizing the cardiac nerves.

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[1] Müller's *Physiology*, by Baly, vol. i. p. 469.

[2] *Ibid.*

[3] *An Experimental Inquiry into the Laws of the Vital Functions*, pp. 111, 213, 256, &c. 3d edit. Lond. 1826.

[4] Müller, *op. ante cit.* p. 549.

But in neither the arteries nor capillaries can contractions be induced by the voltaic current, though Wedemeyer states he has seen a distinct permanent contraction of the small arteries induced by it[1].

CIRCUMSTANCES MODIFYING THE EFFECTS OF THE ELECTRIC CURRENT.—The physiological influence or effects of the current are modified by the following circumstances:—

1. The intensity of the current.
2. The quantity of electricity passing in the current.
3. The direction of the current.
4. The continuance or intermission of the current.
5. The effects of certain diseases or poisons.

1. *The Intensity of the Current.*—The physiological effects of the electric current are greatly modified by its intensity: if the latter be heightened, the effects are increased, and *vice versâ.*

α. The current of electricity obtained from a single pair of plates produces, under ordinary circumstances, no sensible effect on the sense of touch; but, if its intensity be augmented by transmitting it through repeated coils of wire, its effects become very perceptible.

β. A small quantity of electricity, whose intensity is high, produces very powerful effects; as the discharge of the common Leyden jar or battery: whereas a large quantity of electricity, whose intensity is low, produces very feeble or scarcely perceptible effects.

The electricity evolved by Faraday's wire voltaic battery, before described, would be without perceptible effect, on the sense of touch, on account of its feeble intensity. But an equal quantity of electricity, obtained by the ordinary electric machine, and, therefore, of very high intensity, gave a most violent shock; and "if passed at once through the head of a rat or cat," says Dr. Faraday[2], was sufficient "to have killed it as by a flash of lightning."

A certain degree of intensity is required to enable the current to overcome the resistance offered by the animal body to its transmission.

2. *Quantity of the Current.*—The influence of quantity is best seen in those cases where the intensity of the current is great. Thus the power or force of a shock produced by the discharge of the Leyden bottle or battery is proportional to the area of the metallic coating, the intensity of the electricity being equal. In other words, a large Leyden bottle gives a more powerful shock than a small one charged to the same intensity.

When the intensity is low, and the resistance to the transmission of the current is consequently great, the influence of quantity is slight. Thus, in a voltaic battery, composed of a few pairs of plates, no difference is perceptible between the effects of large and small plates.

In coil machines, the power of the shock is augmented by using, as conductors, large metallic surfaces instead of mere wire points; or by moistening the animal surface with a saline solution. By these means the resistance is lessened, and the quantity of electricity which is transmitted is increased.

3. *Direction of the Current.*—To Volta is due the credit of having discovered the modification which the continued passage of an electric current along the nerves effects in the action of the current itself, and which has, in

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[1] Müller, pp. 205 and 228.

[2] *Phil. Trans.* 1834, 7th Series of Researches, § 860.

consequence, been termed the *Voltaic alternatives*. The fact is thus stated by Matteucci:—"The current which is transmitted along a motor nerve of a living or recently-killed animal, and which continues to pass along the nerve during a certain period, modifies the excitability so as to render the nerve insensible to the passage of the current so long as it moves in the same direction; but the excitability of the nerve reappears when the current is made to pass in the opposite direction: so that when a nerve has been modified by the passage of the current in the way described, we may restore to it its lost excitability by reversing the current. Thus, at every change in the direction of the current, the limb, which previously contracted only when we closed the curcuit, becomes now capable of contracting at the interruption of the same circuit."

The different effects of the direct or centrifugal, and of the indirect or centripetal, current on the motor and mixed nerves have been already stated.

Matteucci found that the centrifugal current destroyed the excitability of the nerves much more speedily than the centripetal current.

4. *Continuance or Intermission of the Current.*—An intermitting current (*i. e.* a current alternately interrupted and renewed at very short intervals), excites tetanic convulsions; but sooner exhausts the excitability of a nerve than a continuous current[1].

5. *Effects of certain Diseases and Poisons.*—The effects of electricity are modified by the existence of paralysis. Thus, an electric shock, transmitted through a part affected with paralysis of sensation, produces little or no pain (according as the disease is incomplete or complete); while the effect of a similar shock on a healthy part is very painful. In several cases of hemiplegia, consequent on apoplexy, I have found that the muscular contractions caused by the vibrating current of a coil machine were very feeble in the paralysed limb, while they were very powerful in the healthy one.

Hydrocyanic acid, or a solution of opium, or one of nux vomica, or death by the electric shock, lessens or destroys the excitability of the nerves submitted to the electric current, though the muscles retain their irritability.

Carbonic acid, sulphuretted hydrogen, nitrogen, and *chlorine,* do not possess the power of exhausting the excitability of the nerves.

CHARACTER AND PECULIARITIES OF THE PHYSIOLOGICAL ACTION OF ELECTRICITY ON MAN AND ANIMALS.—Electricity acts on the nervous system of living or recently-killed animals as a stimulant or excitant.

Like heat, alkalies, and mechanical irritation, it excites sensation when applied to the sensitive nerves, and muscular contractions when applied to motor nerves. It further agrees with these stimulant agents in the circumstance that its prolonged action exhausts the nervous excitability; but it differs from other stimulants in several circumstances, of which, according to Matteucci[2], the following are the principal:—

1. The electric current excites either muscular contraction or sensation according to the direction in which it is transmitted along a mixed nerve.
2. The electric current excites neither contraction nor sensation when passed transversely across a nerve.
3. The electric current produces no effect by its prolonged transmission along a nerve.

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[1] Matteucci, *Traité*, p. 232, et seq.

[2] *Ibid.* p. 251.

4. The electric current excites a nerve when it ceases to pass.
5. The electric current restores the excitability of a nerve which had been exhausted by a reverse current.
6. The electric current retains for a longer period than any other stimulant its power of rousing the excitability of a nerve.

CORRELATION OF THE ELECTRICAL AND NERVOUS FORCES. — Between electricity and the *vis nervosa* there exist, both in their development and propagation, several striking analogies, which at one time disposed physiologists to regard these two forces as identical; but the failure of the most competent experimentalists to detect electric currents in the nerves, and the well-ascertained differences in properties between electricity and the *vis nervosa*, have led more recent physiologists[1] to reject the electrical hypothesis of nervous power, which, in the present state of our knowledge, seems to me to be no longer tenable.

USES.—Electricity is employed as a therapeutical agent sometimes rationally, sometimes empirically.

When it is resorted to for the purpose of producing one or more of its known physiological effects, and thereby of fulfilling an indication in the treatment of a disease, its use may be termed *rational*.

But it has been employed in some diseases in which the indications for its use are not obvious, and in which its *methodus medendi*, if, indeed, it possess any curative power whatever, is unknown. In such cases we may term its use *empirical*.

1. *Paralysis.*—Electricity is sometimes beneficially employed in paralysis of sensation or of motion, or of both of these functions. Its operation is that of a peculiar and specific stimulus to the nerves; and hence it is most useful in those cases where these only are affected: while in paralysis from lesion of the nervous centres it holds out but little hope of relief.

In local paralysis, where a single muscle or a set of muscles only is affected; in paralysis arising from a torpid, inactive, or benumbed condition of the nerves themselves; in paralysis, stiffness, and rigidity consequent on chronic rheumatism, bruises, sprains, &c. and after all inflammation and tenderness have subsided; in paralysis arising from poisoning by lead; and, lastly, in all cases of what is sometimes termed functional paralysis, electricity frequently proves highly serviceable: and in some of these cases I have seen the most marked relief follow its use.

In paralysis from permanent organic lesion of the nervous centres, no benefit can be anticipated from its employment.

In the chronic form of paralysis which follows apoplectic attacks from cerebral hemorrhage it is frequently resorted to; but rarely with benefit. In all recent cases, and generally during the existence of inflammatory and febrile symptoms, its use is improper. It must never be applied until sufficient time has elapsed, after the occurrence of the hemorrhage, to allow of the absorption of the coagulum. But when there is reason to suppose or hope that the effused blood has become absorbed, and that paralysis remains from desuetude, the stimulation of the nerves and muscles of the part by an electric current deserves a trial, and may now and then prove serviceable. Moreover, the occasional exercise of the muscles of a paralysed limb, by a weak voltaic current, checks the shrinking of the muscles and loss of irritability consequent on their disuse[1].

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[1] Müller's *Physiology*, by Baly, vol. i. p. 635; Matteucci, *Traité*, p. 252; Todd and Bowman, *Physiological Anatomy*, vol. i. p. 243.

In the application of electricity to the treatment of paralysis, attention should be paid to the *force*, the *duration*, and the *direction* of the current.

a. Force of the Current.—At the commencement of the use of electricity, the current employed should be very feeble: afterwards its force must be adapted to the intensity of the malady. In slight cases, a weak voltaic current may be employed: in more severe cases, a more intense one, or the magneto-electric current, may be used. The shock produced by the discharge of a Leyden phial should be reserved for chronic cases of complete paralysis.

b. Duration of the Current.—This must be governed by the force of the current: the more powerful the current, the shorter should be its duration.

The interrupted or intermittent current should be preferred to the continuous one, care being taken not to apply it long enough to exhaust the excitability of the nerve.

Matteucci recommends that from twenty to thirty shocks should be communicated within two or three minutes, a few seconds being allowed to intervene between each shock. The patient should be then left undisturbed for a few minutes; after which the treatment may be renewed.

c. Direction of the Current.—This is determined by the kind of paralysis. In paralysis of sensation only, the current should be direct or centrifugal; in paralysis of motion, it should be inverse or centripetal. In paralysis both of sensation and motion Matteucci states there are no grounds for preferring the one direction to the other; but it appears to me that for such cases the vibrating current, obtained by the ordinary coil machine, is peculiarly appropriate; for by this the sensitive and motor nerves are alternately excited, while the one current promotes the restoration of the excitability which may have been lessened by the preceding current.

The rule for adapting the direction of the current to the nature of the disease is founded on the assumption that, in some cases of paralysis, the nerves of the affected limb are in a condition similar to that produced by the continued passage of an electric current; and in order, therefore, to restore to the nerve the excitability of which the electric current had deprived it, the current must be reversed. Hence, to relieve paralysis, the current should be passed in a direction contrary to that which may have produced it. Now, as the sensitive nerves act centripetally, the current should be transmitted centrifugally when they are paralysed; and as the motor nerves act centrifugally, paralysis of them requires a centripetal current.

2. In *Amaurosis* of a torpid character, and without excitement, frictional electricity was formerly in considerable repute; but of late years it has fallen into disuse. Mr. Hey[2] published seven cases illustrative of its efficacy; but they are by no means satisfactory; for five of the patients were also mercurialized by calomel, and one received no benefit from the treatment employed. Mr. Ware[3] considered electricity more useful in amaurosis arising from the effect of lightning on the eyes than in any other variety of the complaint. This, indeed, theory leads us to expect.

The mode of using electricity in amaurosis is by the aura, or by slight sparks drawn from or directed against the eye and surrounding parts, or by the current passed either from one temple to the other, or from the superciliary and infraorbitary foramina to the occiput. Theory would indicate the transmission of the current from the hind part of the head to the face; that is, centrifugally as regards the optic nerve.

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[1] Dr. J. Reid, *Edinb. Monthly Journ. of Medical Science*, May 1841.

[2] Hey, *An Account of the Effects of Electricity in Amaurosis*, in the *Medical Observations and Inquiries*, vol. v. p. 1, 2d edit. 1779.

[3] Ware, *Observations on the Cataract and Gutta serena*, Lond. 1812.

3. In *Nervous Deafness*, arising from a torpid condition of the auditory nerve, and unaccompanied with excitement, electricity, both frictional and voltaic, has been frequently employed; and though occasionally patients report themselves benefited by it, in most cases it fails to give relief, and in some instances has aggravated the malady. Both Itard[1] and Kramer[2] speak unfavourably of its effects. After quoting the opinions of most preceding writers on the subject, Kramer observes that, "Looking at the result of all this accumulated experience, given with the utmost honesty, there cannot be one moment's hesitation in declaring that electricity and galvanism are utterly useless in diseases of the ear; that they even seriously endanger the auditory nerve by exciting to a morbid degree its irritability, the infallible result of which is, that it is positively debilitated." My own limited experience of its employment would not lead me to speak so unfavourably of its use.

4. In *Chorea*, considerable relief has sometimes followed the employment of frictional electricity; and I am acquainted with several cases in which its use appeared to be remarkably beneficial. Dr. Addison[3] and Dr. Golding Bird[4] also speak very decidedly of its good effects. I have, however, seen it fail to give relief in a considerable number of cases. Dr. Bird employed it in the form of sparks taken in the course of the spinal column every alternate day for about five minutes each time. Electric shocks transmitted along the limbs never appeared to him to do good, but, on the contrary, often aggravated the involuntary movements. I have seen electric friction in the course of the spine, and centripetally along the nerves of the extremities, apparently relieve the convulsive movements.

5. In *Tetanus*.—The use of electricity in tetanus was first suggested by Matteucci. "We have seen," says this philosopher[5], "that when the passage of the electric current through the nerves of a living or recently-killed animal is renewed many times successively, at short intervals, the limbs remain rigid by tetanic contraction. We know also that, on the contrary, the limbs are paralysed when the current is continued uninterruptedly for a certain time. Hence, then, the effects of the passage of a continued current are altogether different from those of the interrupted one. It was, therefore, natural to suppose that the continued current would destroy tetanus by inducing paralysis. Experience has fully established the accuracy of this conclusion. All narcotic poisons, such as opium and nux vomica, when given to frogs, first stupify, then overexcite them, and lastly, before death, give rise to very violent tetanic convulsions. Now if, during the latter stage, we pass through the animals a continued electric current of a certain intensity, the rigidity of the limbs ceases, and the convulsions disappear. The frogs die after a certain time, but without any symptoms of tetanus. In order to lessen the violence of the

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[1] Itard, *Traité des Maladies de l'Oreille et de l'Audition*, Par. 1821.

[2] *The Nature and Treatment of Diseases of the Ear*, by Dr. Wm. Kramer, translated from the German by Dr. J. R. Bennett, Lond. 1837.

[3] *Guy's Hospital Reports*, vol. ii. p. 493.

[4] *Ibid.* vol. vi. p. 84.

[5] *Traité*, p. 270.

contractions which take place at the commencement of the treatment, it is better to use the inverse current.

"The application of the electric current in a case of tetanus which I published in the *Bibliothèque universelle*, for May 1838, appears to me to prove the correctness of my theoretical conclusions. During the time the patient was under the influence of the electric current, he did not experience the violent attacks which he had had previously. He was able to open and shut his mouth; and his circulation and transpiration appeared to be re-established. Unfortunately, however, these signs of amendment were only temporary; the disease being occasioned and kept up by the presence of foreign bodies in the muscles of the leg.

"I dare not hope that the application of the electric current will in general succeed in curing tetanus; but I think that I am justified in believing that it will relieve, in a great measure at least, the sufferings of the patient."

6. In *Amenorrhœa*, considerable benefit has been obtained by the employment of electricity. It is usually applied in the form of shocks produced by the discharge of a Leyden jar through the region of the uterus (from the sacrum to the pelvis, or from hip to hip). I have on several occasions found the practice successful.

7. *Other Uses.*—The preceding are the chief cases in which electricity is used at the present time. There are, however, many other maladies in which its employment has been suggested; but in some of which the chance of relief has appeared so slight, that the suggestion has never been acted on; in others, experience has not confirmed the expectations which were at first entertained of it; while, in a third class of cases, further experience is required to test its efficacy.

In *asphyxia* from drowning, hanging, the inhalation of noxious gases, &c. voltaic electricity has been unsuccessfully used to excite the muscles of respiration[1]. In *sanguineous apoplexy*, Dr. W. Philip suggested that it might be used to enable the lungs "to perform their functions for a longer time than without this aid," and that by it the life of the patient may be prolonged. In the asphyxia produced by *concussion*, galvanism has been suggested by M. Goudret.

Dr. Wilson Philip, having observed that withdrawing a considerable part of the nervous influence from the stomach and lungs deranges the digestive powers, and produces great difficulty of breathing, was led to expect relief from galvanism in *indigestion* and *habitual asthma*. He describes the benefit obtained as greatly exceeding his expectations. The positive pole is to be applied to the nape of the neck; the negative pole to the pit of the stomach. A weak power should be commenced with, and the strength gradually increased until some uneasiness is experienced. In some instances perfect cures were obtained; in others relief was gained[2].

Prevost and Dumas[3] have proposed to *electrolyze urinary calculi* in the bladder, and thereby to effect their disintegration. Unfortunately, however, for this proposition, calculi are in general formed of substances which are insoluble, or nearly so, and which, therefore, could not be decomposed by an electric current, unless it had a very great intensity, and was continued during a considerable time; in which case it would not be applicable. Bonnet suggested that the bladder should be injected with a solution of nitrate of potash, and the calculus subjected to the action of electricity in this liquid, in order that the nitrate may be decomposed into nitric acid and potash; the former of which it was suggested would dissolve the phosphates, while the latter would dissolve the uric acid and urate of ammonia.

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[1] The Professors of the Irish College of Surgeons, in 1829, failed to restore by it the respiratory movements in a person who had been hung (Dr. Apjohn, in *Cyclopædia of Practical Medicine*, art. *Galvanism*). Electricity, in conjunction with other means, was tried, but without success, in the case of Scott, the American diver, who had been accidentally hung for five or six minutes (see *Times*, Jan. 13, 1841).

[2] See *Phil. Trans.* 1817, p. 22; and Dr. Wilson Philip's *Treatise on Indigestion*. Also, La Beaume, *On the Medical Effects of Electricity and Galvanism in Nervous and Chronic Disorders*, 1820.

[3] *Journal de Physiologie*, t. iii. p. 217.

If the poles or electrodes of a voltaic battery be immersed in an albuminous liquor, the albumen becomes coagulated. On this fact it has been suggested "that galvanism might be applied to the important purpose of *coagulating the blood within an aneurismal tumour*, and thus removing the disease without resorting to the ligature[1]." For this purpose two needles are to be introduced into the tumour, and their projecting extremities connected with the opposite electrodes of the battery.

Pravaz[2] has proposed to *cauterize* the bites inflicted by rabid animals, by introducing the electrodes of a battery into the wound; and Fabré-Palaprat[3] has suggested that the cauterizing effects of the moxa might be effected by voltaic electricity; and in this way a *galvanic moxa* formed.

In 1832, Dr. Coster[4], and in 1833, M. Fabré-Palaprat[5], employed voltaic electricity *to assist the introduction of certain medicinal substances into the blood.* M. Fabré-Palaprat asserts that, by the aid of galvanism, he has caused certain chemical agents to traverse the body and appear at some distant part. He bound on one arm a compress, moistened with a solution of iodide of potassium, and covered by a platinum disk, connected with the negative pole of a voltaic battery of thirty pairs of plates. On the other arm was placed a compress, moistened with a solution of starch, and covered by a platinum disk, connected with the positive pole of the battery. In a few minutes the starch acquired a blue tinge, showing that the iodine had been transported from one arm to the other. I have twice repeated Fabré-Palaprat's experiment; but, though I employed fifty pairs of plates for fifteen minutes, I was unable to obtain the slightest evidence of the passage of iodine through the body.

Electric friction, or slight shocks, are sometimes employed *to promote the biliary secretion;* but I have had no experience of their good effects.

To promote the resolution of indolent tumours, electricity, in the form of sparks, slight shocks, and friction, has been employed, and, it is said, with occasional benefit. I have tried it in several cases of enlarged cervical glands, but without observing that any benefit resulted therefrom.

It has been proposed *to destroy opacity of the crystalline lens* by electricity; but, as Matteucci[6] has shrewdly observed, "though it is possible to make a cataract by the electric current, it is not possible to destroy one by it."

Electricity has been recently applied by Dr. Radford[7] *to produce uterine contractions* in cases of severe flooding attended with exhaustion. Dr. Radford states, that it excites not only tonic contraction, but also alternate contraction, when applied at intervals. In one case he used it where the membranes were unruptured, and the uterus in a state of great inertia; and alternate contraction was immediately produced. He also suggests the use of this agent in tedious labours depending upon want of power in the uterus, and where no mechanical obstruction exists; in cases where it is desirable to produce premature labour; in menorrhagia where the uterus is flaccid, and the os uteri patulous; and in hour-glass contraction, to excite the longitudinal uterine fibres. The apparatus employed by Dr. Radford was a coil machine; one pole being applied to the abdominal parietes over the fundus uteri, the other pole to the os uteri. The vaginal conductor "consists of a strong brass stem, seven inches long, curved to suit the vagina, and covered with a non-conducting material, having a small screw at its distal extremity for attaching it to a silvered ball; at its other extremity it is received within an ebony handle, which is hollow, and through which passes a strong brass wire, looped at the end, and connected with the long wires before alluded to. The wire is kept disconnected from the brass stem by means of a spiral spring concealed within the ebony handle. The loop is covered with silk, and is intended for the thumb of the operator when he is bringing the wire into connection with the stem. When the remedy is applied, the brass ball of the vaginal conductor is to be passed up to the os uteri, and moved about at intervals on to various parts of this organ."

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[1] Apjohn, *Cyclopædia of Practical Medicine*, art. *Galvanism*.

[2] *Revue Médicale*, Dec. 1830.

[3] *Du Galvanisme appliqué à la Médecine*, p. 57, Paris, 1828.

[4] *Archives Générales de Médecine*, t. ii. p. 432.

[5] *Ibid.* 2me série, t. ii. Also, Becquerel, *Traité de l'Electricité*, t. iv. p. 321.

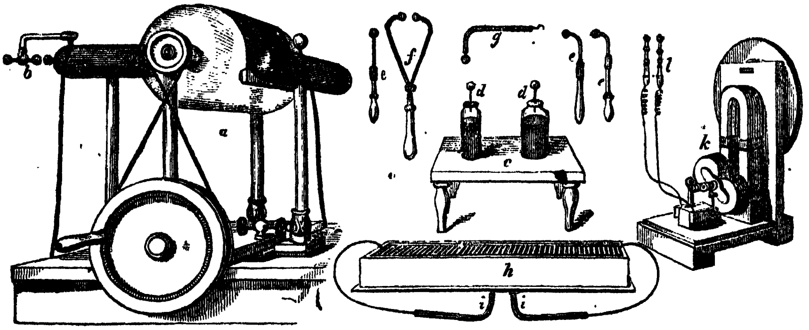
[6] *Traité*, p. 272.

[7] *Provincial Medical Journal*, Dec. 1844. Also, Rankin's *Half-Yearly Abstract*, vol. i.

MODES OF PRODUCTION OF ELECTRICITY FOR MEDICAL PURPOSES.—The sources of electricity are numerous; but of these a few only have been resorted to for obtaining electricity for medical purposes. They are—

1st. Friction, as in the common electrical machine.
2dly. Chemical action, as in the voltaic battery.
3dly. Magnetism, either of temporary magnets, as in the coil machines, or of permanent magnets, as in the magneto-electric machines.

FIG. 1.



Electrical Apparatus for Medical Purposes.

FRICTIONAL ELECTRICITY.

a. Cylinder machine.
b. Medical electrometer.
c. Insulating stool.
d d. Leyden jars.
e e e. Insulated directors.
f. Discharging rod.
g. Glass tube traversed by a wire, which terminates at one end by a loop, at the other by a brass ball.

VOLTAIC ELECTRICITY.

h. Cruickshank's wooden trough.
i i. Directors, each consisting of a glass tube traversed by a wire, an extremity of which is connected with one end of the trough; while the other extremity is surmounted by sponge or flannel moistened with salt and water.

MAGNETIC ELECTRICITY.

k. Clarke's magneto-electric machine.
l. Directors.

1. FRICTIONAL ELECTRICITY.

(Common or Franklinic Electricity.)

APPARATUS.—The apparatus requisite for the medical application of frictional electricity, consists of the following instruments:—

1. *A cylindrical or a plate machine* (fig. 1, *a*). If a cylinder, the diameter should be at least from 8 to 14 inches; if a plate, from 18 to 24 inches. The amalgam used for the rubber is composed of one part tin, two parts zinc, and six parts mercury. The conductor intended for the reception of the electricity is denominated the *positive conductor;* while the conductor attached to the cushion, or rubber, is called the *negative conductor.* Some machines, however, are not fitted up with the latter.

2. *Lane's medical electrometer,* to regulate the force of the spark or shock (fig. 1, *b*).

3. *One or two Leyden jars:* if more than one, they should be of unequal size (fig. 1, *d d*).

4. *An insulating stool or chair* (fig. 1, *c*).

5. *A discharging rod* (fig. 1, *f*).

6. *Two or three insulated directors* (fig. 1, *e e e*). The brass ball which surmounts each director may be occasionally unscrewed and removed, and a metallic or wooden point substituted.

7. *Flexible metallic wire or chain.* A brass chain is generally employed; but the spiral brass wire employed for braces is more convenient: it may be enclosed within a thick silk ribbon.

8. *An ear tube* (fig. 1, *g*), consisting of a narrow glass tube, traversed by a brass or copper wire, which terminates at one end in a small brass ball, at the other by a loop.

The common electric machine yields, by the friction of its glass cylinder or plate on the rubber, a *small quantity* of electricity of *high tension*, or whose elasticity is great, and which, therefore, is capable of exerting attractive and repulsive forces not merely at sensible, but at considerable, distances. The quantity of electricity which is elicited depends on the extent of the rubbing surfaces and the suitability of the substances used. "It has been found by direct experiment, that all kinds of glass are not equally adapted to give out electricity. The best glass is that which is the whitest, most transparent, the hardest and freest from bubbles, and which contains a large proportion of silex. It has also been ascertained that it should not be too thick, in order that the [electrical] fluid may be quickly excited[1]."

The arrow in the following diagram (fig. 2) shows, according to the Franklinian hypothesis, the direction of the current set up by the rotation of the glass cylinder of the machine:—

FIG 2.

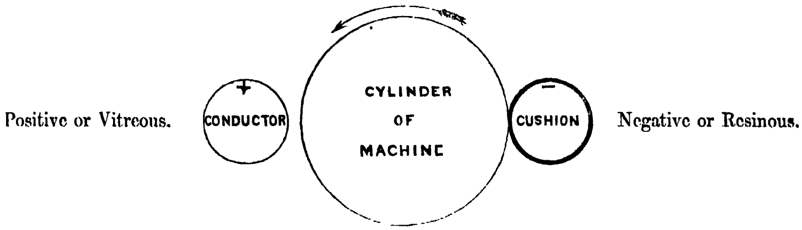


Diagram illustrative of the Direction of the Electric Current in the Cylinder Machine, on the Franklinian Hypothesis.

The glass robs the cushion of electricity, and yields it up to the conductor: the cushion, therefore, becomes negative, while the conductor becomes positive.

FORMS AND MODE OF APPLICATION.—Frictional electricity may be applied medicinally in five forms; viz. the *bath*, the *aura*, the *spark*, the *shock*, and the *current*.

1. *The Electric Bath.*—In this mode of employing electricity the patient is placed on the insulating stool (or chair), and in connection with the prime conductor of the machine. The whole surface of the body becomes electro-positive, while the air which surrounds the body is, by induction, rendered electro-negative. The positive electricity is constantly and silently discharged from all pointed parts of the surface, as from the hairs, fingers, &c. In a darkened room the discharge is seen to be attended with the evolution of light. The effect of the electric bath is not constant (see p. 36).

2. *Electric Aura.*—This is produced by the action of a current of electrified air on the skin. It is applied by means of an insulated pointed director, connected with the prime conductor by a wire or chain; its point being turned to the part intended to be electrified. In this way a current or breeze of highly excited air is directed towards the part. Or the aura may be drawn from the patient while placed on the insulating stool, by means of an uninsulated metallic point. The electric aura operates as a mild stimulant,

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[1] Peschel's *Elements of Physics*, by West, part iii. p. 32, Lond. 1846.

and is occasionally used when we are desirous of electrifying delicate parts; as the eye, ulcers, excoriated surfaces, the testicles, &c.

3. *The Electric Spark.*—This is one form of the disruptive discharge. It may be communicated by presenting to the part to be electrified, the ball or knob of an insulated director connected with the prime conductor. Or it may be drawn from the patient by placing him on the insulating stool (or chair), and bringing the knuckle or the ball of an uninsulated director near him. The opposed surfaces, between which the spark passes, are in oppositely electrified conditions. The nearer they are together, and the smaller the ball, the weaker is the force of the spark. A succession of very small sparks is obtained by substituting a wooden point for the metallic ball.

The spark occasions a sharp, painful, pungent sensation, redness, and sometimes a small circumscribed spot or wheal, which, however, in general quickly disappears.

For internal parts, as the bottom of the meatus auditorius externus, a glass tube is used to insulate the conducting wire, the end of which terminates in a very small knob, contained within, or placed at the end of, the tube (fig. 1, *g*).

A favourite mode of employing electric sparks is *to draw them through flannel*, as recommended by Cavallo[1]. This method is called by some electricians *electric friction*. The patient, being placed on the insulating stool, takes hold of the chain communicating with the prime conductor by the hand opposite to the side to be electrified. Over the naked part is then placed a piece of flannel, and, the machine being turned, the operator places the knob of an uninsulated director in close contact with the flannel, and moves it steadily, but rapidly, so as to draw a vast number of very small sparks. It is said that the motion of the ball should be down the part affected; that is, in the direction of the ramifications of the nerves. The operation is to be continued for twenty or thirty minutes. It excites warmth, but no very disagreeable sensations. When an uneven surface (as of the face and hands) is to be electrified, the ball of the director should be covered with flannel.

4. *The Electric Shock.*—This is a violent effect of the disruptive discharge, and is thus effected:—Charge a Leyden jar; then connect its outside by a chain or wire with the ball of an insulated director, which is to be applied to one extremity of the part through which the electricity is intended to pass. The knob of the jar is then applied to the other extremity of the part, and the discharge instantaneously takes place.

The force or the strength of the charge is graduated by interposing in the circuit a medical electrometer (see fig. 1, *b*), which is employed thus:—Place the Leyden jar so that its interior may be in communication with the prime conductor, while its exterior is connected with the patient by a chain and insulated director. One of the knobs of the electrometer is then put in communication with the opposite side of the patient by a second chain and director. If the machine be now turned, the jar charges, and, when the tension is sufficiently high, a spark passes from the prime conductor to the ball of the electrometer, and the discharge takes place, the patient experiencing the shock. To increase or diminish the force or strength of the shock, we augment or lessen the space between the prime conductor and the ball of the electrometer.

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[1] *Complete Treatise on Electricity*, vol. ii. p. 136, 3d ed. Lond. 1786.

Sometimes a coated glass tube is substituted for the Leyden phial in the above arrangement, the medical electrometer being employed. The patient then receives a rapid succession of slight shocks, constituting what some electricians denominate *electrical vibration*.

When a portion of the body makes a part of the circuit through which the discharge of a Leyden phial is effected, a sudden, instantaneous, and painful sensation is produced, which is denominated *the shock*. If the charge be passed through the arms, the effects are principally experienced in the wrists, elbows, and across the breast. If the diaphragm form part of the circuit, it is immediately thrown into a temporary state of contraction. If a strong charge of a battery be passed through the head of a rabbit, temporary blindness or death ensues. In persons killed by lightning, red streaks are frequently observed on the skin. It is said that marks are often observed indicating the passage of the electric fluid along the spine. The blood is usually fluid, and the muscles flaccid; though occasionally rigidity of muscles has been found.

The greater or less violence of the shock depends not on the quantity merely, but also on the intensity of the charge. Thus a small jar highly charged will produce a greater effect than a large battery feebly charged. But of course, if the intensities be equal, the greatest shock is perceived when the largest quantity is employed.

5. *The Electric Current.*—To cause a current to pass through a patient to the ground, connect some part of the body directly, or indirectly by a chain or wire, with the prime conductor of the machine; the patient standing on the ground. By this means the current passes into the body at the point of connection, and escapes by the feet. Its effects are exceedingly slight, and scarcely, if at all, obvious.

2. VOLTAIC ELECTRICITY.

(Galvanism; Voltaism; Chemical Electricity; Contact Electricity.)

APPARATUS.—The apparatus required for the medical application of voltaic electricity consists of—

1. *A compound hydro-electric battery*, commonly called a *voltaic* or *galvanic battery*. Notwithstanding the improvements which have of late years been effected in the construction of voltaic apparatus, the battery devised by the late Mr. Cruickshank is, for medical purposes, decidedly to be preferred to other batteries of later construction, on the ground both of cheapness and convenience.

It should consist of from 50 to 100 pairs of plates (copper and zinc), each from 2 to 4 inches square, and arranged in one or two wooden troughs (*Cruickshank's troughs*). In most cases, one trough of 50 pairs will be found sufficient. When two troughs are employed, they must be connected together endwise by slips of sheet copper, or stout copper wire—the zinc end of one trough with the copper end of the other trough.

The liquid used to excite the battery may be common water, a solution of common salt, or water acidulated with hydrochloric or sulphuric acid. Common water is employed where very feeble effects are required; as where the skin is very susceptible of the voltaic influence. Acidulated water is used where the most powerful effects are required. One part of hydrochloric acid, and from sixteen to twenty parts of water, may be used. Singer, however, used only one part of acid to five hundred of water. One part of oil of vitriol, and from twenty to thirty parts of water, form as strong a charge as in general is likely to be required. The use of nitric acid is objectionable on account of the nitrous fumes which are evolved.

2. *A pair of insulated directors*, each consisting of a glass tube traversed by a copper wire. One extremity of the wire is in communication with one end of the trough; the

other extremity is covered with sponge or flannel, moistened with a solution of common salt.

3. *Copper wire* to connect the directors with the ends of the troughs.

Simple Voltaic Circuits.—These are occasionally employed as popular remedies, either in the form of Harrington's electrizers or as galvanic rings.

Harrington's electrizers are plates of copper and zinc, or of silver and zinc, made in various forms. Thus for the toothache a plate of copper is soldered edgeways to one of zinc, and worn in the mouth: the saliva serves to excite the apparatus. In another contrivance, an hexagonal plate of zinc is connected by its face to a plate of silver: and a series of these compound plates are connected together by wire, so as to move on each other like hinges. These are worn next the skin for the relief of rheumatism. The perspiration serves to excite the plates. Silver and zinc spangles also have been employed, instead of the plates just mentioned.

Galvanic rings are constructed of copper and zinc, or of silver and zinc. The perspiration is supposed to excite them.

The *intensity* of the electricity evolved by the voltaic battery depends on the number of plates used, and on the chemical nature of the liquid employed to charge the battery. By increasing the number of plates, we proportionately augment the intensity of the electricity; and by increasing the intensity of the chemical action going on in the cells, we also heighten the intensity of the electric current. Thus, the intensity of the current evolved by the use of a solution of common salt is greater than that produced by common water; but is less than that obtained by an acidulated liquid. Moreover, diluted nitric acid yields a more intense current than diluted sulphuric acid.

The *quantity* of electricity evolved by the voltaic battery depends on the size of the plates. But, as plates of from two to four inches square evolve as large a quantity of electricity as is required for medical purposes, it is useless and wasteful to employ plates of larger size.

"This strongly marked distinction in the capacities of batteries consisting of small pairs of plates, and those which are composed of a few large pairs, admits of a satisfactory explanation by Ohm's law[1]. In any case when it is desired that the current should exert a powerful influence on some bad conducting substance, the density of the electricity must be increased as much as possible by employing a great many pairs of plates; and thus the resistance offered to the conduction and transmission of the fluid through its circuit by the interposition, for example, of the human body, is easily overcome: this end would not be attained by increasing the quantity of the electricity, which we might do either by increasing the effective surface or by using more powerful combinations, because, by either of these means, we should reduce only the resistance that we meet with in the battery itself, and that, compared with the resistance of the non-conducting substance that forms a part of the circuit, is, after all, but very small. So, also, we can easily explain why these effects are rendered still more powerful if that portion of the human frame which is enclosed within the wires be moistened with some liquid that is a good conductor: the effect is heightened still further if large metallic surfaces, instead of merely the points of the wires, are brought into contact with the body: by either of these modes, the strong resistance which the human frame offers to the transmission of the electricity is much lessened.

"Suppose we use a single pair of plates, whose electro-motive power we will call 1, and that the resistance of the human body which forms a part of the circuit is 100 times greater than that of the pair of plates, then, by Ohm's formula, the effect of the current on the body may be expressed by the fraction $\frac{1}{1+100} = \frac{1}{101}$. Next use a battery consisting of 100 such pairs, and its effect will be represented by $\frac{100}{100+100} = \frac{1}{2}$, which is much greater than that of the single pair. Now, if we were to employ a single pair of plates with an electro-motive force 100 times greater than that of the pair first spoken of, or, in other words, one whose resistance to conduction shall be 100 times less than that of the former, the effect of its current on the human frame would be only $\frac{1}{\frac{1}{100}+100} = \frac{1}{100{\cdot}01}$, which is but very little more than that of the first pair, whose electro-motive power we supposed to be only $\frac{1}{100}$th of the power of the latter pair[1]."

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[1] Taylor's *Scientific Memoirs*, vol. ii. p. 401.

The direction of the current in the voltaic battery is, on the Franklinian hypothesis, from the more oxidable metal (zinc) to the liquid, and from this to the less oxidable metal (copper, silver, or platinum), as in fig. 3.

FIG. 3.

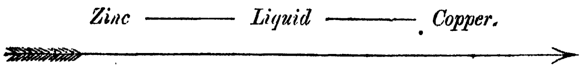
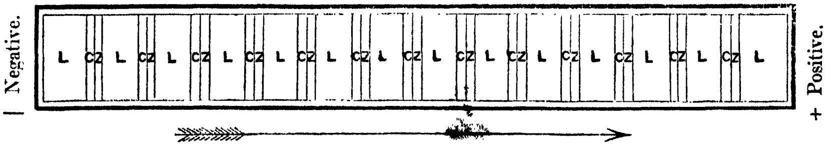


Diagram illustrative of the Direction of the Voltaic Current on the Franklinian Hypothesis.

In Cruickshank's battery, the direction of the current is, therefore, as shewn by the arrow in the following diagram (fig. 4), in which L indicates the liquid, C the copper plate, and Z the zinc plate:—

FIG. 4.



Plan of Cruickshank's Battery.

FORMS AND MODE OF APPLICATION.—In all experiments with the voltaic apparatus, care must be taken that the various parts, by which connection must be made, be perfectly clean, so as to ensure good metallic contact. This is necessary on account of the low intensity of this form of electricity compared with that obtained by the ordinary frictional machine; so that films of oxide, dirt, varnish, &c. readily obstruct the passage of the electricity, and greatly interfere with the action of the battery. On this account, therefore, the extremities of the conducting wires should be carefully cleaned by sand-paper.

Voltaic electricity is usually employed in the form of the *current;* but when an extended series of plates is employed, and energetic chemical agents used to excite them, *shocks* are obtained.

1. *The Voltaic or Galvanic Current.*—This may be administered by interposing between the terminal poles of the battery any portion of the human body through which it is desired to transmit the current. The parts of the body with which the poles are placed in contact should be moistened with water if slight effects are required, or with salt and water when more powerful effects are desired. We do this in order to facilitate the passage of the electricity which, on account of its low intensity, is obstructed by the resistance offered by the dry cuticle. Or the parts may be covered by a sponge or flannel moistened with water, or with salt and water. Or, in the case of the extremities, one extremity may be immersed in water, or in salt and water,

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[1] Peschel's *Elements of Physics*, part iii. p. 115—116, 1846.

connected with one pole of the battery, and contained in a basin; while the other extremity is immersed in another basin of water, or of salt and water, similarly connected with the other pole of the battery. The effect of the battery is greatly heightened by using for the terminal conductors or poles large metallic surfaces. Thus, if it be required to pass a strong current through the arms, let the patient grasp, with his hands well moistened with salt and water, two metallic cylinders connected with the battery.

The number of plates used must depend on the effects produced. It is better, therefore, to commence with a small number (say from 5 to 10), and gradually increase the number until the required intensity be obtained.

As the most powerful effects of the current are produced at the moment of closing or opening the circuit, we can augment the effects by alternately making and breaking the contact of the poles with the body. This is sometimes effected by the rotation of a toothed wheel.

2. *The Voltaic or Galvanic Shock.*—This is effected in the same way as the current, but using a more extensive series of plates (from 50 to 100 pairs), exciting them by an acidulated solution, and employing the means above mentioned for effecting and breaking contact. "The shock of a voltaic battery may be distinguished from that of common electricity, inasmuch as the latter is felt far less deeply, affecting only the outer part of our organs, and being exhausted in a moment. The voltaic shock, on the contrary, penetrates farther into the system; propagating itself along the entire course of the nerves[1]."

Electro-Puncture.

(Galvano-Puncture.)

The operation of electro-puncture was proposed by Sarlandière[2], in 1825. It consists in introducing two acupuncture needles in the usual way, and connecting them with the poles of a weak voltaic battery; the contact being occasionally suspended and renewed, in order to produce a succession of shocks. This practice has been successfully adopted for the relief of rheumatism, neuralgia, local paralysis, sciatica, spasmodic affections, and other maladies in which the operation of simple acupuncture has been used, than which it has been thought, by some, to be more efficacious. In neuralgia and in rheumatism it should be employed only in the interval of the paroxysms[3]. M. Bourgeois[4] proposed to employ the operation of electro-puncture of the heart, to promote resuscitation, in cases of asphyxia. Majendie[5] employs electro-puncture in incomplete amaurosis with great success. "This is done by passing down five needles through any of the branches of the frontal and superior maxillary nerves, a slight pricking sensation indicating that the nerve is pierced; a galvanic current is then passed along the needles through the branches of the fifth nerve."

3. MAGNETIC ELECTRICITY.

Magnetism, when conjoined with motion, excites, by induction, dynamical electricity. Being itself a statical force, it requires the superaddition of motion to produce a dynamical force[1].

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[1] Peschel, *op. cit.* part iii. p. 118.

[2] *Mémoires sur l'Electro-puncture*, Paris, 1825.

[3] Trousseau and Pidoux, *Traité de Therapeutique*, t. i. p. 579, Paris, 1836.

[4] Quoted by Merat and De Lens, in the *Dict. Univ. de Mat. Méd.* art. *Electro-puncture.*

[5] Mackenzie, *A Practical Treatise on the Diseases of the Eye*, p. 857, 3d ed. 1840.

APPARATUS.—The magnets used for the production of magnetic electricity are either *temporary* or *permanent*. Machines in which the former are employed are commonly known as *coil machines;* while those in which the latter are used are called *magneto-electric machines.*

a. Coil Machines.

(Volta-electric Induction Machines; Galvano-magnetic Induction Machines; Electro-dynamic Machines.)

These machines are variously constructed. They consist essentially of the following parts:—

1. *A single voltaic pair.* This is usually called *the battery.* The most convenient construction is that of Mr. Smee, consisting of platinized silver and amalgamated zinc, immersed in water acidulated with about one-eighth part by measure of oil of vitriol.

In the *Improved Graduated Galvanic Coil Machine*, made by Hearder, of Plymouth, the platinized silver plate is one inch and a quarter wide, and three inches long. The acid mixture used to excite this battery consists of one measure of oil of vitriol, and seven measures of water.

2. *A primary and a secondary coil or helix* (made of covered copper wire), *with a core* (consisting of a bundle of soft iron wires), *and a contact-breaker.* The wire composing the *primary, inner,* or *quantity coil* is shorter, but thicker, than that forming the *secondary, outer, induction* or *intensity coil.* The actual thickness and length of the wires vary in different machines. In a coil machine for medical purposes, made by Mr. Newman, of Regent Street, the primary coil contains 80 feet of No. 16 wire; and the secondary coil, 360 feet of wire of about the $\frac{1}{100}$th of an inch in diameter.

3. *A pair of brass or copper directors with glass handles.* The extremity of each director should be armed with a circular brass or copper disk, of about an inch in diameter, and covered with sponge or flannel moistened with either water or a solution of common salt.

When the two extremities of the primary coil are respectively connected with the two poles of the voltaic pair, a voltaic current (called the *primary* or *quantity current*) traverses the primary coil. At the instant of making and breaking contact between the battery and the primary coil, a momentary voltaic current (called the *induced* or *secondary* or *intensity current*) is induced in the secondary coil.

The secondary current obtained by making contact is in the reverse direction to that of the primary current; while that produced by breaking contact is in the same direction as the primary current.

The wires composing the *core* placed in the common axis of the two coils are, during the period of the passage of the voltaic current through the primary coil, magnets (*temporary* or *electro-magnets*): they greatly augment the intensity of the secondary current.

As the secondary current exists only at the moment of making and breaking contact, the use of the *contact-breaker* is obvious.

The secondary current, on account of its having a much higher intensity than the primary current, is used for its physiological influence. As obtained by the apparatus above described, it is an alternating, vibrating, or to and fro current; that is, at the moment of making contact it is in one direction, and at the time of breaking contact it is in the reverse direction. By a slight alteration in the construction of the contact-breaker, this reverse secondary current may be intercepted[1], and we then obtain an intermitting current in one direction only.

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[1] Grove *On the Correlation of Physical Forces*, p. 32, 1846.

The regulation or graduation of the shock is effected in these machines in various ways. One method is by withdrawing partially the core from the axis of the coils: the more it is withdrawn, the less powerful will be the shock.

Another method is by varying the length of the wire composing the secondary coil. This is the method adopted by Hearder in the machine before referred to. By means of a graduated regulator, having a moveable index, no less than sixteen different degrees of power are obtained; the lowest being that produced by a secondary wire of 80 feet in length, the highest by one of 320 feet long.

A third method is the interposition of an imperfect conductor in the circuit of the secondary wire, by which the resistance to the progress of the electricity is augmented. Bonijol, of Geneva, uses for this purpose a water tube, with the conducting wire in contact with the water at each end of the tube. By varying the distance between the extremities of these two wires, or by making them touch each other, the intensity of the shock may be graduated.

The shock of the coil machine is administered as follows:—Having connected the battery with the primary coil, and the directors with the secondary coil, place the moistened extremities of the directors in contact with the two parts of the body between which it is desired that the shock should be passed. Or, if it be desired to pass the shock through the extremities, two basins of water or salt and water, connected respectively with the terminals of the secondary coil, may be used as before described under the head of "Voltaic Electricity."

Dr. Radford's mode of transmitting the current through the uterus has been already noticed (p. 47).

β. *Magneto-electric Machines.*

The apparatus required for the medical application of magnetic electricity consists of—

1. *A magneto-electric machine.* The most convenient, simple, and powerful magneto-electric machine is that devised by Mr. E. M. Clarke, of the Strand. It consists of a battery of six curved *permanent magnets*, and an *intensity armature*, around whose cylinders 1500 yards of fine insulated copper wire are coiled (*intensity coil*).
2. *A pair of directors.* Each of the directors holds a piece of sponge or flannel dipped in vinegar or a solution of common salt.

The ends of the wire composing the *intensity coil* are to be connected with the directors, and these applied to two portions of the living body. When the armature is rotated, a succession of shocks is received by that portion of the living body interposed between the directors.

A magneto-electric machine, like the voltaic battery and coil machines, is not affected by the moist state of the atmosphere: this gives it an advantage over the common electric machine; and as acids are not required to excite it, one inconvenience of the voltaic battery and coil machines is obviated.

It is employed in medicine as a substitute for the ordinary voltaic battery and coil machines. The current which it gives is an alternating or vibrating one, and which I have before alluded to (see pp. 44, and 55—56).

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[1] Dr. Letheby, *London Medical Gazette*, N. S. vol. iii. p. 858. 1846.

5. MAGNETISMUS.—MAGNETISM.

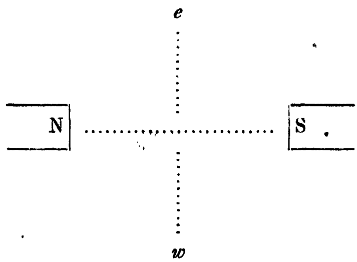
(*Mineral Magnetism.*)

HISTORY.—Aëtius[1], who lived about A.D. 550, is the oldest author who expressly mentions the application of magnetism to the cure of diseases; for, although Hippocrates[2] speaks of the magnet as a remedial agent, he refers to its internal use only. Subsequently to Aëtius, a considerable number of writers have noticed the supposed therapeutical powers of magnets[3]. About the end of the seventeenth century, magnetic tooth-picks and ear-picks were made as secret preventives against pains in the teeth, eyes, and ears[4].

GENERAL REMARKS.—The recent researches of Dr. Faraday[5] have shown that all matter is "subject to the magnetic force as universally as it is to the gravitating, the electric, and the chemical or cohesive forces." But all substances are not affected by the magnetic force in the same manner. Some, when suspended in the magnetic field, arrange themselves axially, or in the lines of magnetic force: these are said to be *magnetic*.

Others, however, whose form is elongated, arrange themselves equatorially, or at right angles to the lines of magnetic force, when similarly suspended: and these are said to be *diamagnetic*.

FIG. 5.



The Magnetic Field.

N S, the *axial* direction, or the direction from pole to pole, or the line of magnetic force.
e w, the *equatorial* direction, or the direction perpendicular to the axial direction, and across the line of magnetic force.

From Dr. Faraday's experiments, it appears that, "besides iron, nickel, and cobalt, the following [metals] are also *magnetic;* namely, titanium, manganese, cerium, chromium, palladium, platinum."

The class of *diamagnetic* bodies is a very extensive one, and includes bismuth, antimony, and many other metals, rock crystal, many earthy and alkaline salts, vegetable and mineral acids, water, alcohol, phosphorus, sulphur, several oily, fatty, and resinous substances, ivory, flesh, blood, &c. "I was much impressed by the fact," says Dr. Faraday, "that blood was not magnetic, nor any of the specimens tried of red muscular fibre of beef or mutton. This was the more striking because iron is always, and in almost all stages, magnetic."

The same philosopher also observes that, "if a man could be suspended, with sufficient delicacy, after the manner of Dufoy, and placed in the magnetic field, he would point equatorially; for all the substances of which he is formed, including the blood, possess this property."

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[1] *Sermo* ii. cap. 25.

[2] *Opera; De intern. affect.* p. 543; and *De his quæ uterum non gerunt*, p. 686, ed. Fœsii.

[3] See the very elaborate and able *Mémoire sur le Magnétisme médicinal*, by MM. Andry and Thouret, in the *Mémoires de la Société Royale de Médecine*, Année 1779, p. 531.

[4] Beckmann, *History of Inventions and Discoveries*, vol. i. p. 74.

[5] *Phil. Trans.* for 1846.

PHYSIOLOGICAL EFFECTS.—As all substances are under the influence of the magnetic force, it might be expected that the vital functions would suffer some modification from the action of magnetism on organised bodies; but hitherto no conclusive and unequivocal evidence on this point has been obtained.

Various phenomena have been ascribed to it; but the inconstancy of their occurrence throws great doubt over the opinion that they are really the effects of the magnetic force[1]. The failure of their production in persons on whose statements confidence can be placed, and their occurrence chiefly in females and in what are called nervous persons, are reasons for suspecting some error or fallacy in the statements of those who advocate the influence of magnetism on the vital functions.

Dr. Faraday does not appear to be susceptible of the magnetic force; for some years ago he allowed Dr. Keil to try, in a variety of ways, the influence of powerful magnets on him, but no perceptible effects were produced[2]; and he informs me that he was never sensible of any effect produced on him by the powerful magnets which he used in his recent experimental investigations on magnetism (see *Phil. Trans.* for 1846), although he purposely submitted various parts of his body to their influence, and tried in all imaginable ways to obtain some evidence of their effect.

On healthy sensitive[3] individuals, says Reichenbach, magnets of 10lb. supporting power, when drawn along the body downwards without contact, produce a sensation rather unpleasant than agreeable. It is "like an *aura*; in some cases warm; in others cool; or it may be a pricking, or a sensation of the creeping of insects on the skin: sometimes headache comes rapidly on." Diseased sensitive subjects "experience different sensations,—often disagreeable, and occasionally giving rise to fainting, to attacks of catalepsy, or to spasms so violent that they might possibly endanger life[4]."

Becker[5] states that the sensations which his patients experienced from the use of the magnet were, 1st, *cold* (probably from the coldness of the steel); 2dly, *heat* (this is the most frequent effect, especially in the ears, and it often amounts to unpleasant burning); 3dly, *traction* (from the slightest degree, when it is an agreeable feeling, to the strongest, when it is almost painful, like that of a cupping-glass); 4thly, *an indefinite sensation* (in the ear, called a working or roaring); 5thly, *throbbing;* 6thly, *pain;* and 7thly, *numbness* or *loss of feeling in the magnetised part.*

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[1] Reichenbach believes that the power of acting on the nervous system enjoyed by artificial magnets is also possessed by the earth's magnetism; by the rays of the sun, moon, and other heavenly bodies; by heat, light, electricity, and chemical action; by crystals; by living persons; and, in a word, by material substances generally. This force or power forms a part, he says, of what is usually called magnetism, and is probably the agent in animal magnetism; but, in reality, it is a force or influence distinct from all known forces; and he proposes, therefore, to call it *od* (a name not possessing any meaning), and according as it is found in crystals, magnets, the living body, heat, light, &c. he terms it *crystallod*, *magnetod*, *biod*, *thermod*, *photod*, &c. (*Researches on Magnetism and on certain Allied Subjects*, by Baron von Reichenbach, translated and abridged by Dr. Wm. Gregory, Lond. 1846).

[2] *Lancet* for 1835-36, vol. i. p. 716.

[3] Persons susceptible of the magnetic influence are said to be *sensitive*.

[4] Reichenbach states, that diseased sensitive subjects enjoy an extraordinary acuteness of the senses. The poles and sides of powerful magnets, the poles of crystals, the human hand, &c. are luminous to them. Luminous appearances (*corpse-lights; ghost-lights;*) are also seen by them over graves; and are due to the chemical changes going on in the corpse!! Reichenbach also asserts, that sleep is more sound and refreshing when the sleeper lies in the magnetic meridian; that is, with his head towards the north, and his feet to the south: and he ascribes the painful and disagreeable feelings which some persons experience in church to the circumstance that churches are built east and west; and "those in front of the altar are necessarily in the position from west to east, which, to all sensitive persons, is the most intolerable!!"

[5] *Der mineralische Magnetismus und seine Anwendung in der Heilkunst*, von C. A. Becker, M.D. Mühlhausen, 1829.

In some instances it has appeared to exercise a most remarkable influence over neuralgic pains and spasmodic affections; at one time apparently curing, at another palliating, and occasionally augmenting all the patient's sufferings. But, in a large proportion of cases, it has failed to produce any obvious effect. The employment of magnetic plates is sometimes attended with itching and an eruption of pimples.

USES.—Toothache, neuralgia, painful affections of the stomach, rheumatic pains, spasmodic asthma, angina pectoris, and palpitation of the heart, are the maladies which have occasionally appeared to be relieved by the magnet. It is said that, in some cases, neuralgic pain is alleviated by the application of the north pole of the magnet, and is augmented by the south pole[1]. Laennec[2] speaks highly of the efficacy of magnetised plates in neuralgia of the lungs, and in angina pectoris. He applied two strongly magnetised oval steel plates, one to the left precordial region, the other exactly opposite on the back, so that their poles were opposed. He says the relief is increased if a blister be applied under the anterior plate. The late Dr. Thomas Davies[3] tried this plan, and with good effect.

Mr. Smee[4] has proposed to detect the existence of needles or other steel bodies impacted in the body, by making the needle magnetic, either by the approximation of a powerful electro-magnet, or by transmitting a current of voltaic electricity along a covered copper wire coiled round the suspected part. When the needle has thus been magnetised, its presence may be detected by bringing in contact with the part containing it a delicate carefully-poised magnetic needle, by the deviations of which the existence of the foreign steel body may be recognised, and even the direction of its poles determined.

APPLICATION.—There are several modes of using magnets. For toothache, a *simple straight* or *bar magnet,* sometimes called *a magnetic staff,* is used. It is first made warm, and its north pole applied to the tooth: if the pain be not relieved, the south pole should then be substituted. Or the poles are applied to, or passed over, the gums or cheeks. In neuralgic pains, *a compound magnet,* called *a magnetic battery,* is commonly employed. This consists of several curved (horse-shoe, lyre-shaped, or U-shaped) magnets, placed one over the other, with all their poles similarly disposed, and fastened firmly together. Dr. Schmidt[5] employed a battery of five magnets of unequal length, the centre one being the longest and thickest. This kind of battery is usually called by workmen *a magnetic magazine. Magnetic collars, girdles, bracelets,* &c. are made of several artificial magnets, with their opposite poles in contact, inclosed in linen or silk. *Magnetised steel plates* (*magnetic plates*), of various forms, are fitted to any part of the body. They are applied to the naked skin, and worn by the aid of a bandage[6].

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[1] *Lancet,* 1832-33, vol. ii. p. 312.

[2] *A Treatise on the Diseases of the Chest,* translated by Dr. Forbes, pp. 402 and 693, Lond. 1827.

[3] *Lectures on the Diseases of the Lungs and Heart,* p. 497, Lond. 1835.

[4] *On the Detection of Needles and other Steel Instruments impacted in the Human Body,* Lond. 1845.

[5] *Lancet* for 1835-36, vol. i. p. 338.

[6] Figures of the different forms of magnetic instruments here referred to are given in Audry and Thouret's *Mémoire* before quoted. For further information on the subject of magnetism, as a

PART III.—HYGIENIC REMEDIES.

(*Remedia hygienica.*)

These are remedies derived from the department of hygiéne.

Under the absurd name of the *non-naturals* (*non-naturalia*), the ancients included six things necessary to health, but which, by accident or abuse, often became the cause of disease;—viz. *air, aliment, exercise, excretions, sleep,* and *affections of the mind*[1]. These are now denominated *hygienic agents*[2].

I propose very briefly to consider, as therapeutic agents, *food, climate,* and *exercise.*

Affections of the mind have been already noticed (see p. 2).

1. CIBUS.—FOOD.

All the substances employed as food are compounds; and in many cases they are mechanical mixtures or chemical combinations of two or more compounds. We may, therefore, most conveniently study them under three heads as follows:—

1. Chemical elements of food.
2. Alimentary principles.
3. Compound aliments.

1. *Chemical Elements of Food.*

Twelve simple or undecompounded substances compose the various articles used by man as food, and are called the *chemical elements* or *elementary constituents of food.* They are as follows:—

1. Carbon.
2. Hydrogen.
3. Oxygen.
4. Nitrogen.
5. Phosphorus.
6. Sulphur.
7. Iron.
8. Chlorine.
9. Sodium.
10. Calcium.
11. Potassium.
12. Magnesium.

Carbon and *hydrogen,* by their oxidation in the system, furnish heat. Liebig estimates the amount of carbon daily consumed by an adult, taking moderate exercise, at $13\frac{9}{10}$ ounces Hessian ($= 15\cdot\frac{3}{10}$ ounces avoirdupoise)[3]; a quantity sufficient to produce as much heat as will daily raise the temperature of 143lbs. (Hessian) of water from the freezing point 32° F. to 98·5° F., the

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medicinal agent, the reader is referred to the works before quoted, as well as to Dr. Bulmerincq's *Beiträge zur ärztlichen Behandlung mittelst des mineralischen Magnetismus*, Berlin, 1835; Dr. Schnitzer's *Ueber die rationelle Anwendung des mineralischen Magnetismus*, Berlin, 1837; and Dr. Most, *Encyklopädie der gesammten medicinischen und chirurgischen Praxis*, art. *Magnetismus mineralis.* 2er Band, S. 394, Leipzig, 1837.

[1] For an account of the non-naturals, consult Sutherland's *Attempts to revive Antient Medical Doctrines*, vol. ii. p. 113, Lond. 1763. Also, Willich's *Lectures on Diet and Regimen*, 3d edit. Lond. 1800.

[2] Rostan (*Dict. de Médecine*, art. *Hygiène*) terms them *Matière de l'Hygiène.* On Hygiène, consult Dr. A. Kilgour's *Lectures on the Ordinary Agents of Life as applicable to Therapeutics and Hygiène*, Edinb. 1834: Dr. Dunglison, *On the Influence of Atmosphere and Locality; Change of Air and Climate; Seasons; Food; Clothing; Bathing; Exercise; Sleep; Corporeal and Intellectual Pursuits, &c. &c. on Human Health; constituting Elements of Hygiene*, Philadelphia, 1835: Sir John Sinclair's *Code of Health and Longevity*, 4 vols. Edinb. 1807.

[3] Liebig's *Animal Chemistry*, edited by Wm. Gregory, M.D. 3d ed. 1846, p. 13.

temperature of the body, besides furnishing the requisite heat for the evaporation of 48 ounces (Hessian) of water through the skin and lungs[1].

Nitrogen is an essential constituent of all foods capable of forming blood and organised tissues. By determining the relative quantities of this element contained in nitrogenised foods, *scales of nutritive equivalents* have been formed[2].

2. *Alimentary Principles.*

These are substances which consist of two or more chemical elements, and are constituents of the compound aliments. They are about seventeen in number:—

1. Fibrine.
2. Albumen.
3. Caseine.
4. Gluten (*Beccaria's*)[3].
5. Gelatine.
6. Oil or fat.
7. Starch.
8. Sugar.
9. Gum.
10. Pectine.
11. Alcohol.
12. Citric, tartaric, &c. acids.
13. Common salt.
14. Earthy phosphates.
15. Certain ferruginous compounds.
16. Potash salts.
17. Water.

They may be arranged in two classes as follows:—

CLASS I. ORGANIC OR CARBONACEOUS ALIMENTARY PRINCIPLES.—These principles are derived from the organic kingdom, and contain each more than one equivalent of carbon. Some of them contain nitrogen; others are devoid of this element. Hence they are divisible into two orders.

Order 1. *Nitrogenised alimentary principles.*—These serve for the formation of blood and living tissues, and have, therefore, been termed *plastic elements of nutrition*. All of them contain carbon, hydrogen, oxygen, and nitrogen; and in some of them sulphur and phosphorus are also present. They may be arranged in two groups.

a. The *albuminous alimentary principles* contain sulphur, and in some cases phosphorus also. They have a composition identical with that of the constituents of the blood; and as they serve for the formation of flesh and blood, they may be termed the *flesh-and-blood-making principles*. They contain for every equivalent of nitrogen eight equivalents of carbon. All of them yield the substance called by Mulder *proteine*[3] ($= C^{40}\ H^{31}\ N^5\ O^{12}$); and hence they may be termed *proteinaceous* principles. The following is the composition of these principles according to Mulder:—

1. Fibrine		$10\ (C^{40}\ H^{31}\ N^5\ O^{12}) + SP$
2. Albumen	of eggs	$10\ (C^{40}\ H^{31}\ N^5\ O^{12}) + SP$
	of serum of the blood	$10\ (C^{40}\ H^{31}\ N^5\ O^{12}) + S^2P$
3. Caseine		$10\ (C^{40}\ H^{31}\ N^5\ O^{12}) + S$
4. Glutin of wheat[5]		$10\ (C^{40}\ H^{31}\ N^5\ O^{12}) + S^2$

Recent investigations[6] conducted in the Giessen laboratory show that the proportion of sulphur in these organic principles has been underrated.

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[1] Liebig, *op. cit.* pp. 44-45.

[2] Boussingault, *Ann. Chim. et Phys.* t. lxiii. pp. 225—244, 1836; Schlossberger and Kemp, *Lond. Ed. and Dubl. Phil. Mag.* vol. xxvii. p. 350, 1845; Pereira, *Treatise on Food and Diet*, p. 55, 1843.

[3] Raw or common gluten of wheat, sometimes called Beccaria's gluten, is only partially soluble in alcohol. The portion dissolved is called *glutin*, and the undissolved portion is *zymome*, or *vegetable fibrine*.

[4] *Proteine*, so called by Mulder, from πρωτεύω, *I hold the first place*, "because it is the origin of so many dissimilar bodies, and is itself, therefore, a primary substance."

[5] "By *glutin*, I mean the substance which can be extracted by alcohol from Beccaria's gluten." —(*Mulder*).

[6] Rüling, Walther, and Verdeil, in the *Annalen der Chemie und Pharmacie*, Bd. lviii. 1846.

β. The *gelatigenous alimentary principles* do not furnish proteine; but by boiling in water they yield a jelly, whence they are termed gelatinous, or more correctly gelatigenous, principles. They are not adapted by their composition for the formation of flesh and blood, but appear to serve for the reproduction of the gelatinous tissues,—such as the skin, cellular membrane, cartilage, and membrane. This division of alimentary principles includes—

1. Common gelatine or collin (gelatinous tissues and tendons) . $C^{48}\ H^{41}\ N^{7\cdot5}\ O^{18}$
2. Chondrine .... $C^{48}\ H^{40}\ N^{6}\ O^{20}$
3. Gelatine of the elastic tissues (*e. g.* arterial membrane)...... $C^{48}\ H^{38}\ N^{6}\ O^{16}$

The formulæ assigned to these bodies are those given by Liebig[1]. Recently Verdeil[2] has detected sulphur in chondrine and isinglass. In the latter substance, however, it appeared to be in the form of an oxygen compound.

Order 2. *Non-nitrogenised organic alimentary principles.*—These principles consist of carbon, hydrogen, and oxygen. The ultimate purpose which they serve in the animal economy is that of furnishing carbon, and, in some cases, hydrogen also, for the support of the function of respiration, and consequently for the production of animal heat: hence they are termed *elements of respiration.* Some of them contribute to the formation of fat[3], while others appear to serve some other but not very obvious purposes in the animal economy.

The non-nitrogenised alimentary principles may be conveniently arranged in three groups thus—

a. Non-nitrogenised alimentary principles whose oxygen and hydrogen are in the same ratio as in water.—This order contains starch, gum, sugar, and acetic acid.

1. Acetic acid (dry) .... = $C^{12}\ H^{9}\ O^{9}$
2. Starch .... = $C^{12}\ H^{10}\ O^{10}$
3. Cane sugar (crystallised) .... = $C^{12}\ H^{11}\ O^{11}$
4. Gum .... = $C^{12}\ H^{11}\ O^{11}$
5. Sugar of milk (crystallised) .... = $C^{12}\ H^{12}\ O^{12}$
6. Grape sugar .... = $C^{12}\ H^{14}\ O^{14}$

Starch by digestion is converted into sugar. Both starch and sugar, when taken as food, contribute to the formation of fat[4]. Gum, though closely related by composition to both starch and sugar, differs from both of them in several particulars. Unlike starch, it does not appear to be convertible into sugar; and it differs from sugar in not being resolvable into alcohol and carbonic acid by fermentation.

β. *Non-nitrogenised alimentary principles whose oxygen is to the hydrogen in a less proportion than in water, or which contain an excess of hydrogen.*—These substances furnish hydrogen as well as carbon for the function of respiration:—

1. Alcohol .... = $C^{4}\ H^{6}\ O^{2}$
2. Fat (hydrated oleic acid) .... = $C^{36}\ H^{34}\ O^{4}$

Various facts concur in proving that alcohol, when employed moderately, disappears wholly or partially in the organism; and we conclude that its carbon and hydrogen become oxidized, and are given out in the form of carbonic acid and water. Alcohol, therefore, must be an element of respiration. When alcohol is used immoderately, part of it is always thrown out of the system as alcohol.

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[1] *Animal Chemistry*, p. 126, 1842.

[2] *Ann. d. Chem. u. Pharm.* Bd. lviii. S. 320—322, 1846.

[3] On the fatty nature of the nucleoli of cells, and on the use of fatty matter in growth and nutrition, healthy and diseased, see Gulliver, in *The Works of Hewson*, published by the Sydenham Society, 1846, footnote, p. 88.

[4] At present butyric acid is the only fatty acid which has been artificially produced from sugar.

Oily or fatty substances used as food supply fat to the system, and contribute to support the function of respiration.

γ. *Non-nitrogenised alimentary principles whose oxygen is to the hydrogen in a proportion greater than is necessary to form water.*—In this order we have the following substances:—

1. Pectine .... = $C^{12} H^{8.5} O^{11}$
2. Citric acid (dry) .... = $C^{12} H^{5} O^{11}$
3. Tartaric acid (dry) .... = $C^{8} H^{4} O^{10}$
4. Malic acid (dry) .... = $C^{8} H^{4} O^{8}$

Although all these agents ultimately act as elements of respiration, yet some of them appear to serve some other important but not very obvious use in the animal economy; since the employment of the acids or their salts, as found in succulent vegetables and fruits, appears necessary for the preservation of health; complete and prolonged abstinence from them being a cause of scurvy.

CLASS II. INORGANIC OR NON-CARBONACEOUS ALIMENTARY PRINCIPLES.—Water, iron (in some state of combination), earthy phosphates, chloride of sodium, and other alkaline salts, are the inorganic constituents of the body. Of these, water and chloride of sodium are alone used in the uncombined state as aliments: the other ingredients are obtained in combination with organic alimentary substances.

3. *Compound Aliments.*

These are mechanical mixtures or chemical combinations of two or more alimentary principles. They are either solid or liquid, the latter being termed drinks. Those which are employed at the table for flavouring or seasoning are called condiments. We may, therefore, conveniently consider them under three heads—

1. Solid foods.
2. Liquid foods or drinks.
3. Condiments or seasoning agents.

1. SOLID FOODS.—Man derives his food from both animals and vegetables. We may, therefore, conveniently divide compound foods into animal and vegetable.

a. Animal Foods.—These are obtained from various classes of animals. Those in common use in this country are as follows:—

MAMMALIA: The ox, sheep, deer, hog, hare, rabbit, &c.
AVES: The common fowl, pigeon, pheasant, partridge, turkey, goose, duck, &c.
REPTILIA: The green or edible turtle.
PISCES: Mackarel, salmon, herring, sprat, white bait, cod, haddock, flat fish, eel, &c.
MOLLUSCA: The oyster, mussel, cockle, scallop, periwinkle, limpet, and whelk.
CRUSTACEA: The lobster, crab, prawn, and shrimp.

The parts of animals used are the ***flesh, blood, viscera, bones, cartilages, ligaments, cellular tissue,*** and ***eggs.***

The alimentary principles, exclusive of ***water*** and ***saline matters,*** derived from solid animal foods, are ***fibrine, albumen, caseine, gelatine,*** and ***fat.***

The relative proportions of water, fibrine or albumen, and gelatine, in the flesh of various animals, is thus stated by Mr. Brande[1]:—

Composition of Flesh.

100 *Parts of Muscle.*	*Water.*	*Albumen or Fibrine.*	*Gelatine.*	*Total of Nutritive Matter.*
Beef	74	20	6	26
Veal	75	19	6	25
Mutton	71	22	7	29
Pork	76	19	5	24
Chicken	73	20	7	27
Cod	79	14	7	21
Haddock	82	13	5	18
Sole	79	15	6	21

β. *Vegetable Foods.*—These are derived from a great number of natural orders. Those in most frequent use are as follows:—

Exogens or Dicotyledons.

1. *Cruciferæ:* Cabbage, turnip, and mustard.
2. *Byttneriaceæ:* Cacao.
3. *Ternstræmiaceæ:* Tea.
4. *Aurantiaceæ:* Orange and lemon.
5. *Ampelideæ:* Grape.
6. *Leguminosæ:* Peas and beans.
7. *Rosaceæ:* Strawberry and raspberry.
8. *Amygdaleæ:* Almond, plum, peach, and cherry.
9. *Pomaceæ:* Apple and pear.
10. *Cucurbitaceæ:* Cucumber and melon.
11. *Umbelliferæ:* Carrot and parsnip.
12. *Compositæ:* Artichoke, lettuce, and endive.
13. *Oleaceæ:* Olive.
14. *Solanaceæ:* Potato.
15. *Chenopodiaceæ:* Spinage and beet.
16. *Polygoneæ:* Rhubarb.
17. *Euphorbiaceæ:* Tapioca.
18. *Urticaceæ:* Figs and mulberries.
19. *Amentaceæ:* Chestnut and hazelnut.
20. *Juglandaceæ:* Walnuts.

Endogens or Monocotyledons.

21. *Marantaceæ:* Arrow-root and tous les mois.
22. *Bromeliaceæ:* Pine apple.
23. *Liliaceæ:* Onion, leek, and asparagus.
24. *Palmaceæ:* Cocoa nut, sago, and date.
25. *Gramineæ:* Cereal grains or corn, and sugar cane.

Cryptogamia.

26. *Lichenes:* Iceland moss.
27. *Algæ:* Laver, carrageen, Ceylon moss.
28. *Fungi:* Common mushroom, morel, and truffle.

The parts of plants used as food are the *seeds* (embryo and albumen), *fleshy pericarps, leaves and petioles, buds and young shoots, stems, tubers,* and *roots.*

The *seeds* are of two kinds: farinaceous and oleaginous. The *farinaceous seeds* used as food are corn, peas, beans, lentils, and the chestnut. The *oleaginous seeds* are the walnut, hazel and filbert nut, cocoa nut, cashew nut, pistachio nut, and stone pine nut.

The alimentary principles, exclusive of *water* and *saline principles,* derived from plants, are *fibrine, albumen, caseine, gluten, oil, sugar, starch, gum, pectine,* and certain *organic acids.*

Corn or the cereal grains, the most important of all vegetable foods, consist of *starch, fibrine, albumen, glutin, mucine, oily matter, sugar, gum, earthy phosphates, ligneous matter,* and *water.*

The relative proportions of water, starch, gluten, albumen, &c. in corn and some other vegetable foods is as follows[2]:—

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[1] *Manual of Chemistry.*

[2] Krocker, in *Pharmaceutical Journal,* Feb. 1847.

Corn and other Vegetable Foods.	*Water.*	Anhydrous Substances.		
		Starch.		*Gluten, Albumen.*
	Per cent.	I. Per cent.	II. Per cent.	Per cent.
Wheat flour, No. 1, from Vienna	13·828	65·21	66·16	19·16
" No. 2, "	16·650	66·93	57·80	13·54
" No. 3, "	12·731	57·70	57·21	21·97
Talavara wheat, from Hohenheim	15·432	55·92	56·59	16·54
Sandomir wheat " "	15·480	53·83	52·92	17·18
Whittington wheat " "	13·930	53·06	51·84	17·11
Rye flour, No. 1, from Vienna	13·780	61·62	60·56	11·94
" No. 2, "	14·680	54·84	54·12	18·71
" from Darmstadt	13·660	57·07	57·77	......
Rye (*Secale cereale*, winter corn), from Hohenheim ...	13·940	45·39	44·80	17·75
" (*Secale cereale arundinaceum*) " " ...	13·820	47·71	47·13	15·77
White oats (*Avena satira*) " " ...	12·940	37·93	36·90	18·00
Kamtschatka oats (*Avena sativa*) " " ...	12·710	39·55	40·17	15·26
Barley flour, from Darmstadt	12·560	64·63	64·18	......
Jerusalem barley (*Hordeum distichon*), from Hohenheim	16·970	42·66	42·03	14·74
Barley (*Hordeum vulgare*), from Hohenheim	13·800	38·62	37·99	17·81
Maize, from Hohenheim	14·960	65·88	66·80	14·68
Maize flour "	13·359	77·74	......	13·66
Buckwheat flour, from Vienna	15·120	65·05	......	6·89
Tartarian buckwheat (*Polygonum tartaricum*), Hohenh.	14·120	43·80	44·45	9·96
One-grained wheat (*Triticum monococcum*), from Giessen	14·400	55·51	53·76	13·22
Rice, from Giessen	15·140	85·78	86·63	7·40
Beans, from Vienna	13·415	37·71	37·79	28·54
Peas "	13·430	38·81	38·70	28·22
Lentils (*Ervum Lens*), from Giessen	13·110	39·62	40·08	......
100 *Parts of the Air-dry Substances contained in their usual condition*—				
Potatoes, No. 1 (blue), from Giessen	68·94	23·20	22·80	2·37
" No. 2 (white), "	74·95	18·14	17·98	2·49
" No. 3	76·80	15·48	16·09	......
		Cane Sugar.		
Beet-root	81·61	10·20	10·48	2·03
Mangel-wurzel	82·25	12·22	12·31	2·04

2. Liquid Foods or Drinks.—These may be arranged under six heads as follows:—

1. Mucilaginous, farinaceous, or saccharine drinks; as toast water, gruel, mucilage, &c.
2. Aromatic or astringent drinks; as tea, coffee, chicory, cocoa, and chocolate.
3. Acidulous drinks; as lemonade, ginger beer, &c.
4. Animal broths; as beef tea, mutton broth, &c.
5. Emulsive or milky drinks; as milk.
6. Alcoholic drinks; as beer, wine, and ardent spirit.

3. Condiments or Seasoning Agents.—Most of the agents used under this name are themselves more or less alimentary, and, therefore, serve some more important purpose than that of merely gratifying the appetite.

The substances usually denominated condimentary may be arranged in five classes as follows:—

1. Saline condiments.
2. Acidulous condiments.
3. Oily condiments.
4. Saccharine condiments.
5. Aromatic and pungent condiments.

Salt, vegetable acids, oils and fats, and sugar, are in fact alimentary principles, and have been before noticed. The aromatic and pungent condiments owe their peculiar properties to volatile oil or resin, and are devoid of nutritious properties.

2. EXERCITATIO.—EXERCISE.

(*Gymnastics.*)

Exercise is an important hygienic agent; but its proper consideration requires far more space than can be devoted to it in this work. I must, therefore, content myself with a few remarks on its general effects, and refer the reader to other works in which it is more fully considered.

Though the word exercise, in its most extensive signification, has reference to the action of all the organs of the animal economy, yet it is usually limited to those of locomotion; and in this sense I employ it.

The exercise of the muscular system is followed by several effects, which may be conveniently arranged under four heads; viz.

1. Mechanical effects.	3. Nervous effects.
2. Organic or vital effects.	4. Mental effects.

1. *Mechanical Effects.*—Whenever the muscles are called into activity, they exert a local influence, of a mechanical kind, on the blood-vessels in their immediate vicinity, and thereby accelerate the circulation of the blood. This is followed by an augmentation of the animal heat; and, if the exercise be of a kind to call into activity a considerable number of muscles, the general circulation soon participates in the effects; the pulse is quickened, and the respiration and secretions are augmented. Another effect, which, in its origin, is probably of a mechanical nature, is the absorption of the fat between the muscles and their fasciculi, and which seems to arise from the pressure exerted by the contracted muscle on the soft tissues immediately around it.

2. *Organic or Vital Effects.*—This includes the augmentation of volume, of firmness, of elasticity, and of strength or power, which a muscle acquires from frequent but moderate use. Blacksmiths, fencers, and prize-fighters, furnish excellent illustrative examples of these effects.

3. *Nervous Effects.*—The action of the muscles can only be effected through the medium of the nervous centres and nerves: the latter, therefore, are called into activity, and through them the whole system becomes influenced by the exercise of a number of muscles.

4. *Psychical or Mental Effects.*—To this head belong the different mental effects produced by agreeable and disagreeable,—by voluntary and compulsory,—exercises. Employed moderately, agreeable exercise acts as a salutary excitant to the intellectual faculties and sensations. I agree with the late Dr. James Johnson[1], "that travelling exercise, while it so much improves all the bodily functions, unhinges and unfits the mind, *pro tempore*, for the vigorous exercise of its higher faculties." But the first excitement being over, "the memory of scenes and circumstances, together with the reflections and recollections attendant thereon, furnish an ardent mind with

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[1] *Change of Air, or the Pursuit of Health and Recreation*, 4th edit. 1838.

rich materials and trains of thought, that may, by gifted individuals, be converted into language; and thus conveyed to thousands."

Thus, then, exercise, employed moderately, has a tonic and stimulating influence on the system, and is calculated to be beneficial in a great variety of complaints. Used immoderately, it exhausts both the mental and bodily powers, and produces great debility. In fever, in vascular excitement or inflammation of the brain, in inflammatory affections of the lungs, in maladies of the circulating organs (especially dilatation of the cavities of the heart, diseased valves, and aneurism), in violent hemorrhages, gastro-enteritic inflammation, acute rheumatism, &c. muscular exertion is manifestly injurious; repose and inaction being indicated. In sprains and lacerations of the muscles, in fractures and dislocations, &c. it is obviously improper. In hernia, or a tendency thereto, great muscular exertion must be carefully avoided.

Exercises may be divided into the *active*, the *passive*, and the *mixed*. To the first belong walking, running, leaping, dancing, fencing, wrestling, &c.; to the second are referred, carriage exercise and sailing; while horse exercise belongs to the third or last division[1].

An important part of the treatment of distortions of the spine which are unconnected with caries consists in the employment of particular exercises contrived with the view of strengthening the muscles of the back. "All climbing exercises," says Sir B. Brodie[2], "are useful in this respect, bringing all the muscles of the spine into vigorous action. They are at the same time beneficial in another way, the weight of the lower limbs tending to elongate and strengthen the column of the vertebræ. A rope, with worsted wound round it, that it may not hurt the hands, may be suspended from the ceiling, and the patient will soon become a dexterous climber. There are often two or three girls in a family for whom this exercise will be beneficial; and that which would be a tedious and irksome task to a girl alone, will become an amusement when pursued in the company of others of her own age. The handswing affords a very useful exercise in these cases also. This is a triangle composed of a double rope, with a cross-bar of wood forming the base of the triangle, suspended from the ceiling at such a height that the individual who uses it can just reach the cross-bar with her hands as she stands on tip-toe. She is to hold the bar with both her hands, and swing with her feet raised a little from the ground. The effect of this exercise also is to bring the muscles of the spine into action, at the same time that the weight of the lower limbs operates in the same manner as when she climbs a rope. At first probably she will not be able to continue to use the handswing for more than a few seconds at a time; but as she grows stronger she will swing for a much longer period. Another mode of exercising, and thus strengthening the muscles of the back, is the following:—Let one pulley be fixed to the ceiling, and another to the floor. Let a small rope pass over the upper pulley and under the lower pulley, a box containing a light weight being fastened to that end of the rope which is nearest to the upper pulley, and a handle to that which is nearest to the lower pulley. The patient, standing with her face towards the pulleys, is to raise and lower the weight, holding the handle in both her hands. The effort used in raising the weight necessarily calls the muscles of the back into action; and as the patient becomes accustomed to it, the required effort may be increased by putting an additional weight into the box. This exercise may be varied by taking off the handle and fixing the rope to a bandage fastened round the head, so that the weight is raised by the action of the muscles of the neck and back without the aid of the arms. The latter method of using the pulleys, however, is wearisome to the patient, and practically much less useful than the other."

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[1] For further information on the subject of Exercise, the reader is referred to Celsus, lib. i. cap. 2, and lib. ii. cap. 15; Sir J. Sinclair's *Code of Health and Activity*, Edinb. 1807; Dunglison's *Elements of Hygiène*, Philadelphia, 1835; *Dict. de Médecine*, art. *Gymnastique*; *Dict. de Médecine et de Chirurgie pratiques*, art. *Gymnastique*; *Manuel d'Education physique, gymnastique et morale*, par le Colonel Amoros, Paris, 1830.

[2] *Lond. Medical Gazette*, Jan. 1, 1847.

3. CLIMA.—CLIMATE.

Under the word Climate are included those topographical, atmospheric, and other conditions of a region or country, which have a beneficial or injurious influence on the health and lives of the inhabitants[1].

I shall briefly notice the subject under three heads.

1. Phenomena of climates.
2. Climates most frequently used as therapeutical agents.
3. Diseases for which change of climate is employed.

1. PHENOMENA OF CLIMATES.

It is probable that we are yet ignorant of many circumstances which contribute to produce the climatic character of a place; and, of those that are known, it is often not easy to define the separate influence of each.

The most obvious circumstances which affect the climate of a region or country, are *temperature, humidity, purity of the atmosphere, wind, atmospheric pressure, intensity of light, atmospheric equability* or *vicissitudes, soil, amount of vegetation,* and *proximity to the sea.*

1. TEMPERATURE.—In considering the temperature of a place, we must regard, not merely its annual mean, but its extremes. Inland tracts of country experience greater extremes than the coasts, in consequence of the land being more rapidly heated and cooled than water. Hence it attains a higher temperature in summer, and a lower one in the winter. It is also deserving of notice that the western coasts of the extra-tropical continents have a much higher mean temperature than the eastern coasts. This is explained by the heat evolved in the condensation of vapour swept from the surface of the ocean by the western winds[2]. The effects of heat and cold on the human body have been already considered[3]. Liebig ascribes the frequency of diseases of the liver in hot seasons and tropical climates to the accumulation of carbon in the system. This he thinks arises from the consumption of too much food; and from the inspiration of a smaller quantity, by weight, of oxygen than in cold climates and cold seasons, in consequence of the air being expanded by the heat. *Warm climates* are adapted for pulmonary invalids (especially consumptive patients), the rheumatic, the scrofulous, the paralytic, and those who suffer from the effects of a feeble circulation. *Cold,* or rather *moderately cool,* climates are bracing, and fitted

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[1] Dr. Shirley Palmer, in his *Pentaglot Dictionary,* defines climate as "an extent of country wherein all the circumstances which exercise an influence upon organised beings are nearly the same. Again, the assemblage of all these circumstances and conditions, exclusive of organic texture, on which life depends, and which exert upon it a perceptible operation."

[2] Daniell's *Meteorological Essays,* p. 105, 2d edit. Lond. 1827.

[3] See pp. 12, 13, 23, 24, and 25.

for relaxed constitutions. Cold weather and cold climates are injurious to the aged, the paralytic, the phthisical, the scrofulous, the diabetic, and the rheumatic.

2. HUMIDITY. *Hygrometric State of the Atmosphere.*—Evaporation from the cutaneous and pulmonary surfaces is augmented by a dry, and checked by a damp or moist, state of the atmosphere. But the transudation which depends on vital action is augmented by warmth and moisture[1]. "Of all the physical qualities of the air," observes Sir James Clark[2], "humidity is the most injurious to human life." Intermittents and even phthisis have been ascribed to it[3]. A *moist* climate checks evaporation; and, therefore, a *soft* climate is adapted for chronic bronchitis of a dry irritable kind, frequently denominated dry catarrh, and for some other maladies attended with a harsh, dry, parched skin. A *dry* climate, on the other hand, promotes evaporation, and, therefore, is better fitted for relaxed, languid constitutions, with profuse secretion and exhalation; as humid asthma, and those forms of chronic catarrh which are accompanied with copious expectoration.

As aqueous vapour is the chief fluctuating ingredient of the atmosphere, it is probable that to its varying quantities must be ascribed many of those feelings and conditions of the body popularly referred to the weather. "There are days," says the late Professor Daniell[4], "on which even the most robust feel an oppression and languor, which are commonly and justly attributed to the weather; while on others they experience exhilaration of spirits, and an accession of muscular energy. The oppressive effect of close weather and sultry days may probably be accounted for from the obstruction of the insensible perspiration of the body, which is prevented from exhaling itself into the atmosphere, already surcharged with moisture; while unimpeded transpiration from the pores, while the air is more free from aqueous vapour, adds new energy to all the vital functions. In bodies debilitated by disease, indeed, the contrary effects may be produced: they may be unable, from weakness, to support the drain of free exhalation which is exhilarating to the healthy; and hence probably arises the benefit of warm sea breezes in cases of consumption and diseases of the lungs."

3. PURITY OF THE ATMOSPHERE.—A pure condition of the atmosphere is an essential element of all healthy climates. The greater mortality of cities than of the country is principally referable to the respiration of air vitiated by the congregation of a large number of persons in a comparatively limited space. Air contaminated by the exhalations or effluvia from wet lands, swamps, marshes[5], animal and vegetable substances in a state of decomposition[6], and human bodies, especially those of the sick, is a prolific cause of disease. The aëriform poison thus introduced into the atmosphere is called *miasma* (*μίασμα*, a stain or pollution), or *malaria* (an Italian word, derived from *mala*, bad, and *aria*, air). Its chemical nature is unknown. Gaseous exhalations from the earth in volcanic and other districts form another source of local atmospheric impurity[7]; and to those must be added

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[1] Edwards, *De l'Influence des Agens Physiques*, p. 338, Paris, 1824.

[2] *The Sanative Influence of Climate*, 3d ed. Lond. 1841.

[3] Forcault, *Causes générales des Maladies chroniques, spécialement de la Phthisie Pulmonaire, et Moyens de prévenir le Développement de ces Affections*, Paris, 1844.

[4] *Elements of Meteorology*, vol. ii. p. 310, Lond. 1845.

[5] The production of Ague, by the exhalations from stagnant water and marshy soils, is well known to every one.

[6] The late Professor Daniell (*Lond. Edinb. and Dubl. Phil. Mag.* July 1841,) found in sea water brought from the Western coast of Africa sulphuretted hydrogen; and he suggested that the existence of this deleterious gas in the atmosphere, which must necessarily accompany its solution in the waters, may be connected with the awful miasma which proves so fatal to the explorers and settlers of the deadly shores of Africa, as well as of other places. But the gas which he obtained from these waters must have been developed after they were bottled; for neither in the river nor sea water, when fresh collected, can a trace of sulphuretted hydrogen be detected. (See Dr. M'William's *Medical History of the Expedition to the Niger during the years* 1841—2, Lond. 1843, pp. 160—175 and 190—193; also Dr. Pritchett's *Account of the African Remittent Fever*, Lond. 1843, pp. 117—118).

The origin of sulphuretted hydrogen in sea and some other waters has been ascribed, by Dr. Marcet (*Phil. Trans.* 1819, p. 195), Mr. Malcomson (*Trans. of the Geological Society*, 2d Ser. vol. v. p. 564, Lond. 1840), Dr. A. Fontau (*Ann. de Chem. et de Phys.* July 1840), and Professor Daniell (*op. supra cit.*), to the decomposition of sulphates of the waters by putrifying vegetable matter.

[7] *Carburetted hydrogen* (CH^2) issues from coal strata, and is also evolved from the earth in other situations where there is no reason to suspect the presence of coal. *Carbonic acid gas* (CO^2) is abundantly set free in volcanic and other districts. To this gas the Guevo Upas or Valley of Poison in Java (*Journal of Geographical Society*, vol. ii.), and the Grotto del Cane (*Med. and Phys. Journ.*

the vapour, smoke, or fumes from various chemical works[1]. The injurious effect of fogs on asthmatic patients is well known to every one. Curiously enough, however, some patients affected with spasmodic asthma breathe better in a smoky atmosphere (as that of London) than in pure air.

4. Wind.—Wind greatly modifies the effect of temperature on the body. Thus two successive days, whose temperature, as indicated by the thermometer, may be the same, shall produce in us—the one a sensation of warmth, in consequence of the calm, still, condition of the air; while the other creates a feeling of cold, from the presence of a violent wind. So that, as Sir James Clark[2] has justly observed, "the influence of temperature on the living body is indicated much more accurately by our sensation than by the thermometer." Moreover, the humidity and the purity of the atmosphere are greatly modified by the motion or calmness of the air. The precise effects produced on climates by wind must of course depend on its direction, violence, &c. "Common experience has proved that in all countries the winds which have blown over large tracts of land are much drier than those which proceed from the sea[3]."

5. Atmospheric Pressure.—The total amount of atmospheric pressure on a man of ordinary stature may be estimated at about 30,000lbs.; and a fall of half an inch in the column of mercury in the barometer is equivalent to a reduction of about 500lbs. atmospheric pressure on the body. Now it can scarcely be doubted that variations of atmospheric pressure must exert some influence over the functions of healthy, but especially of diseased, persons. It is difficult, however, to estimate, separately from other co-existent influences, the precise effects which result from these variations. Diminished atmospheric pressure promotes evaporation; and hence this is one reason why elevated regions, which are colder, drier, and more bracing than low situations, are, *cæteris paribus*, better adapted for relaxed individuals, with profuse secretion and exhalation, than the last-mentioned localities; but, on the other hand, they are injurious in bronchial or tracheal irritation, with diminished secretion.

A fall in the barometer is generally produced by an augmentation of aqueous vapour in the atmosphere; and the deposition of moisture[4] which ensues is attended with the evolution of heat. These atmospheric conditions have a powerful influence over the animal economy; for, in consequence of the diminished atmospheric pressure, the superficial vessels become gorged, and secretion is readily effected; while, from the humid condition of the air, evaporation does not take place. Hence arise a feeling of languor and fatigue, and sweating on the slightest exertion. In bronchitis, with profuse secretion, the patient's danger is greatly aggravated by diminished atmospheric pressure indicated by a sudden fall in the barometer, and by the accompanying augmented humidity of the air.

6. Intensity of Light.—The influence of light has been already considered (see p. 7).

7. Atmospheric Equability or Vicissitudes.—Rapid atmospheric changes are always injurious to health, and, therefore, climates which are subject to sudden changes of temperature, or of humidity, or of atmospheric pressure, or of wind, are invariably unhealthy. Invalids, and those with delicate constitutions, often appreciate the slightest alterations in the condition of the atmosphere, and which are not observable by the healthy and the robust.

8. Soil.—The climate of a place is also greatly modified by the quality of the soil. Sandy and gravelly soils allow the rain to percolate rapidly through them, and are, therefore, called *dry soils*. Chalky soils are also called dry, though they are less so than the preceding. Sandy, gravelly, and chalky soils are in general most salubrious. They are peculiarly fitted for relaxed constitutions with profuse secretions. Clayey soils are called *wet soils*, because they retain the rain on their surface. They are in general less salubrious than the preceding, and often are positively injurious to health. They prove most obnoxious to relaxed and rheumatic constitutions. Marshy and swampy soils are most injurious to health, and have been already noticed as sources of malaria.

Oct. 1832), owe their remarkable properties. It has been calculated that 219,000,000 lbs. or about 1,855,000,000 cubic feet of carbonic acid are exhaled annually in the vicinity of the Lake of Laach (De la Beche, *Theoretical Geology*).

[1] See the articles *Arsenious Acid* and *Hydrochloric Acid*.

[2] *Op. supra cit.* p. 156.

[3] Daniell, *op. cit.* vol. i. p. 215.

[4] In extra-tropical climates, a fall in the barometer, without a change or rise of wind, is usually followed by rain.

Soils also deserve to be considered with reference to the greater or less rapidity with which they become heated or cooled. Sir H. Davy[1] observes, that stiff white clay soils, as well as chalky soils, are with difficulty heated by the sun; while the black, dark coloured, and carbonaceous soils are much more rapidly heated.

9. AMOUNT OF VEGETATION.—The character of a climate is often affected by the exuberance or deficiency of vegetation. Jungles, woods, and forests, protect the earth from the action of the solar rays, and are, in consequence, often the residence of moisture and decaying vegetation analogous to a marsh[2].

10. INLAND AND MARITIME LOCALITIES.—In general, the climate of places on the sea shore is more humid than those of inland localities; but to this statement there are many exceptions. (See also *Temperature*).

These are some only of the circumstances which affect the quality or character of a climate. Others doubtless exist; but their precise nature and influence have scarcely been ascertained. For example, we have yet to learn the influence of Electricity and Magnetism on the climate of a place.

2. CLIMATES MOST FREQUENTLY USED AS THERAPEUTICAL AGENTS.

I propose, now, to glance at the characters of those climates most commonly resorted to by invalids for therapeutical purposes. In doing so, I have to acknowledge the great assistance which I have received from Sir James Clark's valuable work on *The Sanative Influence of Climate,* to which I must refer the reader for further details.

Climates may, for the purpose just mentioned, be conveniently arranged as follows:—

1. Climates of England.
2. Climates of France.
3. Climates of Spain and Portugal.
4. Climates of Italy and the Mediterranean.
5. Climates of the Atlantic.

1. *Climates of England.*

"The British Islands are situated in such a manner as to be subject to all the circumstances which can possibly be supposed to render a climate irregular and variable. Placed nearly in the centre of the temperate zone, where the range of temperature is very great, their atmosphere is subject, on one side, to the impressions of the largest continent of the world; and, on the other, to those of the vast Atlantic Ocean. Upon their coasts the great stream of aqueous vapour, perpetually rising from the western waters, first receives the influence of the land, whence emanate those condensations and expansions which deflect and reverse the grand system of equipoised currents. They are also within the reach of the frigorific effects of the immense barriers and fields of ice, which, when the shifting position of the sun advances the tropical climate towards the northern pole, counteract its energy, and present a condensing surface of immense extent to the increasing elasticity of the aqueous atmosphere[3]."

Sir James Clark thus arranges the climate of England:—

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[1] *Elements of Agricultural Chemistry.*

[2] Macculloch, *Malaria,* Lond. 1827.

[3] Daniell's *Meteorological Essays,* p. 114, 2d ed. 1827.

1. London.
2. The South Coast.
3. South-west Coast.
4. Cornwall, Land's End.
5. West of England.

1. LONDON.—The mean annual temperature of London is about 50°·4[1]. It somewhat exceeds that of the suburban parts. The following is an abstract of the averages of seventeen years' meteorological observations (from 1826 to 1842) made in the garden of the Horticultural Society at Chiswick, about six miles west of London:—

Temperature.	Fah.
Mean in the shade	49°·94
Maximum in the shade	94°·4
Maximum in the sun	130°
Minimum in the shade	−4°·5
Minimum radiation	−12°·0

Dew Point.	Fah.
Mean	47°·36
Maximum	79°
Minimum	0°

Barometer.	Inches.
Mean	29·931
Highest	30·856
Lowest	28·597

Rain.	Inches.
Mean	24·16
Maximum	30·97
Minimum	18·87

Wind.

Average Number of Days in the Year during which each Wind prevails.

	N.	NE.	E.	SE.	S.	SW.	W.	NW.
Mean	24·4	47·2	37·1	21·8	56·8	79·8	65·8	31·7
Maximum	38	75	56·	38	77	126·	90	61
Minimum	17	30	17	11	38	58	46	18

"The excess of the temperature of the city varies through the year, being least in spring, and greatest in winter; and it belongs, in strictness, to the nights, which average 3·7° warmer than in the country; while the heat of the day, owing, without doubt, to the interception of a portion of the solar rays by a constant veil of smoke, falls, on a mean of years, about a third of a degree short of that in the open plain[2]." Hence, in the winter, delicate invalids sometimes experience benefit in coming to London from the country. But the impure state of the atmosphere frequently counterbalances these good qualities[3]. In some cases of spasmodic asthma, however, respiration is easier in London than in the country.

2. SOUTH COAST.—This comprehends the tract of coast between Hastings and Portland Island. Its mean annual temperature is about that of London; but the summers are somewhat cooler, and the winters somewhat warmer, than the corresponding seasons of the metropolis[4]. Its light is very intense. For invalids, the superiority of the climate of the South Coast over that of the metropolis is greatest during December, January, and February.

The principal places of resort for invalids, on this line of coast, are the following:—

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[1] *Elements of Meteorology*, vol. i. p. 141.

[2] See Luke Howard's *Climate of London*, 1818—20, 2d ed. 1833.

[3] For further details respecting the Climate of London, consult Professor Daniell's *Essay* on this subject. Also, Dr. Bateman's *Reports of the Diseases of London*, Lond. 1819; and Sir A. Carlisle, *Medical Topography of London*, in his *Practical Observations*, Lond. 1838.

[4] For the characters of this part of England, consult Dr. Harwood's *Curative Influence of the Southern Coast of England, especially that of Hastings; with Observations on Diseases to which a Residence on the Coast is most beneficial*, Lond. 1828. Also, Dr. Mackness's *Hastings Considered as a Resort for Invalids*.

α. *Hastings.*—A mild winter residence; placed low, and well protected from the northerly winds; but fully exposed to winds from the south. Sir James Clark[1] regards its climate "as somewhat intermediate between that of Devonshire and Clifton; less warm, but also less relaxing than the former. It is about the same temperature; but less dry and bracing than the latter, and it is inferior to it as a spring climate." It is well adapted for pulmonary invalids, who desire to avoid the north-east winds, during the months of December, January, and February (especially the two latter months). The distinguished author above quoted declares that it "is unfavourable in nervous complaints, more especially in nervous headaches connected with, or entirely dependent upon, an irritated condition of the digestive organs, and also in cases where a disposition to apoplexy or epilepsy has been manifested." With the exception of St. Leonard's, Hastings has an atmosphere more completely marine than almost any other part of this coast. Hastings has appeared to me unfavourable to rheumatic constitutions.

St. Leonard's is about a mile from Hastings, and possesses a similar climate.

β. *Brighton.*—The air is dry and bracing; and the soil dry. That part of the town east of the New Steyne is considerably elevated above the sea, has a dry chalky soil, in a pre-eminent degree possesses a dry, sharp, bracing air, and is best adapted for relaxed constitutions. That part of the town west of Cannon Place has a clayey soil, and a milder and softer air; and, according to Mr. Wigan[2], includes the most salubrious portion of the town. It is better suited for delicate nervous invalids than the other parts. The central portion of the town is low and somewhat misty, and possesses the usual annoyances of a district placed in the midst of a large town. The Steyne has a climate intermediate between that of the eastern and western portions. The climate of Brighton is most beneficial during autumn and the early part of winter, when it is milder and more steady than that of Hastings. From the middle of March to the middle of May, Mr. Wigan advises invalids to stay away altogether from Brighton. It is adapted for relaxed individuals, with copious secretion and exhalation. It usually agrees well with children (especially those of a scrofulous habit) and convalescents. Brighton is not adapted for persons affected with congestive diseases of the venous system, inflammatory dyspepsia, or renal diseases, except, according to Mr. Wigan, albuminaria. Brighton is entirely free from marshy and swampy grounds, and is remarkably devoid of trees.

γ. *Isle of Wight.*—Undercliff presents an agreeable, mild, equable, sheltered, dry, bracing climate, well adapted for the residence of pulmonary and other delicate invalids throughout the year. It is well protected from the north winds, and has a dry soil. It differs from the climate of Torquay (which is soft, humid, and relaxing), by its dry and bracing qualities, and its greater equability of temperature. Hence it is suited for relaxed constitutions, with copious secretion. For pulmonary invalids, the best season to reside at Undercliff is from November to May; and at Ventnor will be found good accommodations for the sick.—Cowes and Ryde, on the opposite side of the island, are delightful summer residences.

δ. *Southampton.*—This part of the coast is objectionable, on account of its temperature being equally variable with that of the environs of London.

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[1] *Op. supra cit.* p. 177.

[2] *Brighton and its Three Climates*, Lond. 1843.

3. SOUTH-WEST COAST. *South Coast of Devon*[1].—This comprehends the tract of coast extending from Portland Island to Cornwall. Its general qualities are those of a mild, soft, humid climate, soothing but somewhat relaxing. It "has a winter temperature nearly two degrees higher than that of the coast of Sussex and Hampshire, and from three to four higher than that of London. The difference is most remarkable during the months of November, December, and January; amounting, on the average, in the sheltered places, to five degrees above London," (Sir J. Clark). It is adapted to pulmonary affections, especially those which are attended with a dry cough, and are unaccompanied with much expectoration. In dyspepsia, with symptoms of irritation or inflammation, constituting the gastritic dyspepsia of Sir James Clark, it is also beneficial. But in all forms of chronic diseases, with copious secretion and exhalation, and a languid and relaxed state of the constitution, it is injurious.

The following are the principal places of resort for invalids along the South-West Coast, taking them in succession from east to west:—

α. *Sidmouth.*—The climate is damp, and, in November, is subject to sea fogs.

β. *Salterton.*—Preferable to Exmouth. It is well protected from winds, especially the northerly ones.

γ. *Exmouth.*—The higher parts of the town exposed to winds; the lower parts liable to occasional damp. Sir J. Clark declares that it is not adapted for persons with delicate chests.

δ. *Dawlish.*—Next in dryness to Torquay.

ε. *Teignmouth.*—Mild, humid, and relaxing.

ζ. *Torquay.*—This is drier than the other parts of this coast, though its general character is soft and humid. It is almost entirely free from fogs. It is in great repute as a residence for pulmonary invalids.

η. *Salcombe.*—The Montpelier of Huxham. The warmest spot of this coast.

4. SOUTH COAST OF CORNWALL. *Land's End.*—In its general characters this climate resembles that of the south coast of Devon. From the latter, however, it differs, in its greater humidity, and in being more exposed to winds. It is, consequently, more relaxing. The class of cases in which it is calculated to be beneficial or injurious are much the same as those for the south coast of Devon[2].

The following are the chief places of residence for invalids along this coast:—

α. *Penzance.*—Exposed to the north-east winds during the spring months. Its climate is much more equable than that of London. Thus, though its mean annual temperature is only 1°·77 higher than that of London, yet its winter is 5½° warmer, its summer 2° colder, its spring scarcely 1° warmer, and its autumn about 2½° warmer.

β. *Falmouth.*—The winter temperature is a trifle lower than that of Penzance.

5. WEST OF ENGLAND.—Under this head are grouped the places along the

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[1] For an account of the climate of this coast, see Dr. Shapter's *Climate of the South of Devon.*

[2] On the climate of this part of England, consult Dr. Forbes's *Observations on the Climate of Penzance and the District of the Land's End,* Penzance, 1820. Also his *Medical Topography of the Land's End,* in the *Provincial Medical Transactions,* vol. ii.

borders of the Bristol Channel and the æstuary of the Severn. The mean temperature of this group is, during the winter, rather lower, but in March and April rather higher, than that of the south coast.

Clifton.—This is the mildest and driest climate in the West of England. It is bracing, and well adapted for scrofulous and relaxed constitutions, with copious secretion and exhalation.

2. *Climates of France.*

The southern climates of France resorted to by invalids may be divided into those of the South-West and those of the South-East of that country.

1. SOUTH-WEST OF FRANCE.—According to Sir. James Clark, the climate of this part of France is soft, relaxing, and rather humid; resembling in its general qualities that of the south-west of England. It is favourable to phthisical invalids, for those labouring under bronchial affections, with little expectoration, and for other chronic cases attended with a dry skin.

α. *Pau.*—Dr. Playfair[1] thus sums up the qualities of this climate:—"Calmness, moderate cold, bright sunshine of considerable power, a dry state of atmosphere and of the soil, and rains of short duration. Against these must be placed,—changeableness, the fine weather being as short-lived as the bad; rapid variations of the atmosphere within moderate limits. In autumn and spring there are heavy rains." The season extends from September to June[2].

β. *Bagneres de Bigorre*, in the department of the High Pyrenees, has a mean temperature, during the months of June, July, August, and September, of 66° F. Dr. Wm. Farr[3] declares the climate to be anti-irritating and moist, and to be favourable to the consumptive. It is also beneficial in irritation of the mucous membrane of the trachea and bronchi, with dry cough and viscid expectoration; and also in gastric irritation[4]. Its season is from June to September.

2. SOUTH-EAST OF FRANCE.—Sir J. Clark says the general character of the climate is dry, hot, and irritating. It is adapted for torpid, relaxed habits, but is decidedly improper for the consumptive and those labouring under irritation and inflammation of the air-tubes.

α. *Montpelier.*—Long but undeservedly celebrated as a residence for phthisical invalids.

β. *Marseilles.*—Exposed to cold winds. Soil dry and arid.

γ. *Hyeres.*—Sir J. Clark declares it to be the least exceptionable residence in Provence for the pulmonary invalid.

3. *Climates of Portugal and Spain.*

Precise information respecting the climates of these countries, to which pulmonary invalids occasionally resort, is much to be desired.

1. PORTUGAL.—Dr. Bullar[5] states that the mean annual temperature of *Lisbon* is 12° F. higher than that of London; and that the mean temperature

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[1] Sir J. Clark's *Sanative Influence of Climate*, p. 192.

[2] Dr. Taylor *On the Curative Influence of the Climate of Pau*, Lond. 1845.

[3] *A Medical Guide to Nice*, Lond. 1841.

[4] Dr. Taylor, *op. cit.* p. 243.

[5] *A Winter in the Azores*, Lond. 1841.

of its winter is 16° F. higher than that of London. But notwithstanding its mildness, it is objectionable for persons affected with phthisis, on account of the inequality of its temperature.

2. SPAIN.—Biscay is subject to sudden and extraordinary changes in temperature, the mercury having been known to rise and fall from 3° to 4° F. within a few minutes[1]. This must, of course, make it an unfit residence for pulmonary invalids.—Madrid is elevated more than 300 fathoms above the level of the sea. Its annual mean temperature is 59° F.[2]—Cadiz, being nearly surrounded by the sea, has a comparatively temperate climate.

4. *Climates of Italy and the Mediterranean.*

The climates included under this head are exceedingly diversified, so that it is difficult to lay down any general character of them.

α. Nice. —The climate of this place is somewhat similar to that of the South-East of France. It is mild, equable, and dry; being adapted for torpid, relaxed individuals, with abundant secretion from the mucous membranes. Dr. William Farr[3] says, the great objection to it is its dryness, and the exciting and irritating nature of its atmosphere. It is beneficial in chronic bronchitis, with copious expectoration; in chronic rheumatism; scrofula; gout; and atonic dyspepsia. It is prejudicial in tubercular disease.

β. Genoa.—Climate dry and healthy, with a sharp exciting air. It is adapted for relaxed constitutions, but is unfit for phthisical invalids.

γ. Florence.—Not favourable for invalids.

δ. Pisa.—According to Sir James Clark, the climate "is genial, but rather oppressive and damp. It is softer than that of Nice, but not so warm; less soft, but less oppressive, than that of Rome." Pisa is frequented by consumptive invalids.

ε. Rome.—The climate of this city is one of the best in Italy. Sir James Clark characterises it as being mild, soft but not damp, rather relaxing and oppressive, and remarkable for the stillness of its atmosphere. It is well adapted for phthisis, bronchial affections of a dry irritating kind, and chronic rheumatism.

ζ. Naples.—The climate of Naples is warm, variable, and dry. Sir James Clark compares it to that of Nice, but states that it is more changeable, and, if softer in the winter, is more humid. Dr. Cox[4], however, declares that the mean diurnal variation is far less than is generally supposed. It is an unsuitable residence for most pulmonary invalids, especially those affected with tubercular phthisis. In bronchial cases, with profuse secretion, benefit is sometimes obtained from it. In general debility and deranged health it is also serviceable. Dr. Cox says it is beneficial in dyspepsia, rheumatic neuralgia, and scrofula.

η. Malta.—The climate of Malta is mild, dry, bracing, and pretty equable. It is serviceable in chronic bronchitis with profuse secretion, scrofula, dyspepsia, and hypochondriasis.

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[1] Inglis, *Spain in* 1830, vol. i. p. 39, Lond. 1831.

[2] Humboldt, in De Laborde's *View of Spain*, vol. i. p. clxiii. Lond. 1809.

[3] *A Medical Guide to Nice*, p. 10, Lond. 1841.

[4] *Hints for Invalids about to Visit Naples*, p. 17, Lond. 1841.

5. *Atlantic Climates.*

The climates of the Atlantic islands resorted to by invalids may be arranged in two groups; the one eastern, the other western.

1. Eastern Atlantic.—This group includes Madeira, the Canaries, and the Azores.

α. *Madeira.*—The climate of Madeira is mild, humid, equable, and steady. Sir James Clark regards it as the finest in the northern hemisphere. It is superior to all other climates for incipient phthisis. This superiority consists in the mildness of the winter, the coolness of the summer, and the remarkable equality of the temperature during the night and day, as well as throughout the year. Experience, moreover, seems to have fully demonstrated the advantage which patients, with incipient symptoms of consumption, derive from a residence in this island[1].

β. *The Canaries.*—Teneriffe is the only island of this group possessing accommodation for invalids. Though its mean annual temperature is higher than that of Madeira, its equability is less.

γ. *The Azores or Western Islands.*—Dr. Bullar declares these to be "rather colder than Madeira, and somewhat more equable, and perhaps more humid; but they have not at present those accommodations for strangers which the latter island possesses, nor have they communications by steam with England[2]." St. Michaels, the largest of the Azores, has a mild, humid, equable climate.

2. Western Atlantic.—This group includes the Bermudas, the Bahamas, and the West Indies. It is more subject to rapid changes of temperature than the Eastern Atlantic group.

α. *The Bermudas.*—The climate is warm, variable, and dry. The mean annual temperature is considerably higher than that of Madeira; but the climate is variable and windy during the winter, and hot and oppressive in the summer (Sir J. Clark).

β. *The Bahamas.*—The climate is warm, but is subject to rapid changes of temperature. Dry cold winds prevail. Hence the Bahamas are unsuited to consumptive invalids.

γ. *The West Indies.*—The temperature of these islands is too high, and its variations too great, to admit of their being a desirable residence for patients affected with pulmonary consumption; but as a prophylactic for those predisposed to this disease, it is highly spoken of. In scrofula, the climate proves beneficial. Calculous complaints and ossific deposits are rare. The most healthy islands of the group are Jamaica, Barbadoes, St. Vincent's, Antigua, and St. Kitt's.

3. Diseases for which Change of Climate is Employed.

The diseases for which change of climate is most frequently resorted to are as follows:—

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[1] For further information respecting the medical qualities of the island of Madeira, the reader may refer with great advantage to Sir James Clark's work, before cited; Dr. Gourlay's *Observations on the Natural History, Climate, and Diseases of Madeira*, 1811; Dr. Renton, in the *Edinburgh Medical and Surgical Journal*, vol. xxvii. 1817; and Dr. Heineken's paper in the *Medical Repository*, vol. xxii. 1824.

[2] *A Winter in the Azores*, Lond. 1841.

1. Pulmonary complaints, especially phthisis, chronic bronchitis resembling phthisis, asthma, hæmoptysis, and diseases of the larynx and trachea.
2. Dyspeptic and hypochondriacal complaints.
3. Chronic rheumatism.
4. Scrofula.
5. Urinary diseases.
6. Liver complaints.
7. In the convalescence from fever, and other acute maladies.

1. Pulmonary Complaints.—These maladies are benefited by removal from a colder to a warmer climate. Equability, purity, and calmness of the atmosphere, are other desirable qualities in a climate for pulmonary invalids. The nature of the malady and constitution of the patient, however, render all climates possessed of these qualities not equally suited for every case.

a. *Phthisis*.—"For such consumptive patients," observes Sir James Clark, "as are likely to derive benefit from climate, I consider that of *Madeira* altogether the best. *Teneriffe* and the *Azores* approach most nearly in the character of their climate to Madeira." Of the climates of the South of France and Italy the same experienced writer says, when "there exists much sensibility to harsh and keen winds, and, more especially, if immediate vicinity to the sea coast is known to disagree, *Rome* or *Pisa* is the best situation for a winter residence. When, on the contrary, the patient labours under a languid feeble circulation, with a relaxed habit, and a disposition to congestion or to hemorrhage rather than to inflammation,—and, more especially, when the sea air is known by experience to agree,—*Nice* deserves the preference." Late experience has shewn, that *Montpelier, Marseilles*, and other places in the south-east of France, once celebrated as affording a good winter climate for consumptive patients, are decidedly improper for phthisical invalids. Of English climates, those of *Undercliff, Torquay*, and *Hastings*, are best adapted for this disease. *Torquay* and *Penzance* disagree with persons of a relaxed habit. *Clifton*, during the spring months, often agrees well.

β. *Chronic Bronchitis*.—In relaxed constitutions, with copious expectoration, the climates of *Undercliff, Clifton, Brighton*, and *Nice*, are those which agree best. But, on the other hand, for dry, bronchial, and tracheal irritation, *Torquay, Madeira, Rome*, and *Pisa*, are to be preferred.

2. Dyspepsia and Hypochondriasis.—In selecting a climate for these complaints, we must attend to the character of the malady and the constitution of the invalid. Thus, in the atonic dyspepsia of relaxed and sluggish individuals, with copious secretions, we select a dry and bracing climate; and in such, *Brighton, Clifton, Nice*, or *Naples*, would probably prove beneficial. But when the dyspepsia assumes an inflammatory form, with dry tongue and a febrile condition of system, the soft and humid climates are to be preferred; such as *Torquay, Pau, Rome*, and *Pisa*.

3. Chronic Rheumatism.—In this malady, mild climates generally have been found beneficial. According to Sir James Clark's experience, *Rome* and *Nice* are the best climates on the continent. In relaxed and cachectic individuals, the latter place is to be preferred.

4. Scrofula.—In this malady the *West Indies* proves highly serviceable. *Nice* and *Rome*, on the continent, have appeared to be favourable. In this country *Clifton* is perhaps the climate best adapted for scrofula.

5. Urinary Diseases.—Warm climates relieve most affections of the

urinary organs, especially calculous complaints, diabetes, and vesical irritation. The benefit probably arises from the excitement of the skin and the abundant cutaneous secretion, and is to be explained on the principle of antagonism already alluded to (see p. 12). In the *West Indies* calculous complaints are very rare.

6. LIVER COMPLAINTS.—Various hepatic derangements are induced by a residence in tropical climates (see p. 13); and in such cases benefit is obtained by a return to the more temperate climates of Europe.

7. In the CONVALESCENCE after fevers and inflammatory diseases, change of climate is often found highly beneficial.

PART IV.—MECHANICAL AND SURGICAL REMEDIES.

The consideration of these subjects does not fall within the province of this work.

PART V.—PHARMACOLOGICAL REMEDIES.

(*Medicines; Medicamina;* Φάρμακα.)

PHARMACOLOGICAL REMEDIES OR MEDICINES are substances, not essentially alimentary, used in the treatment of diseases, and which, when applied to the body, alter or modify its vital actions.

ALIMENTS are vital stimuli (see p. 8, footnote), which vivify, and can themselves be vivified; since they are assimilated to our organs, and become integrant parts of the living body.

POISONS are distinguished from medicines principally in the *degree* of their effects, and the *uses* to which they are applied; for the most powerful poisons become, when administered under proper regulations, very valuable medicines.

PHARMACOLOGY (*pharmacologia,* from φάρμακον, *a medicine;* and λόγος, *a discourse*), or MATERIA MEDICA, is that branch of Acology (see p. 1) devoted to the consideration of medicines. It is subdivided into three departments:—

1. Pharmacognosy.
2. Pharmacy.
3. Pharmacodynamics.

1. PHARMACOGNOSY (*pharmacognosia,* from φάρμακον, *a medicine;* and γιγνώσκω, *I know*) is that department of Pharmacology which treats of the origin, properties, varieties, quality, and purity of *unprepared medicines* or *simples* (*medicamenta cruda*). In other words, it treats of all that relates to the commerce of drugs.

This department of pharmacology is also called by various other names; as *physiographical materia medica* (physiographische Arzneimittellehre[1]), *pharmacography*[2] (pharmacographia, from φάρμακον and γράφω, *I write*), *pharmacomathy*[1] (pharmacomathic, from φάρμακον and μάθω, *I seek or inquire*), *pharmaceutical merchandize-knowledge* (pharmaceutische Waarenkunde[2]), and the *history of simple drugs* (histoire des drogues simples[3]).

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[1] Pfaff, *System der Materia Medica*, 1er Band. S. 2, Leipzig, 1808.

[2] A. A. Da Silveira Pinto, *Pharmacographia do Codigo Pharmaceutico Lusitano*, Coimbra, 1836.

2. PHARMACY (*pharmacia*, from φάρμακον, *a medicine*,) is that department of Pharmacology which treats of the collection, preparation, preservation, and dispensation of medicines (*medicamenta præparata et composita*).

This department of pharmacology is sometimes called *chemical materia medica* (chemische Arzneimittellehre[4]), *pharmacotechny* (pharmacotechnic[5]), *pharmaceutical chemistry* (pharmaco-chemia), and *pharmaconomia*[6].

The *collection* of unprepared medicines or simples involves their selection, emendation or preliminary preparation, and desiccation. *Simples* are either *foreign* or *indigenous*. The former are imported by the merchant, and sold on his behalf, by the drug-broker, to the wholesale druggist.

Indigenous vegetable substances are usually collected by the simpler (ῥιζοτόμος[7]) or herbalist. Most of the plants grown in this country, and for which there is a large consumption, are cultivated at Mitcham and other places.

The *preparation* of medicines has for its object the division, separation, mixture, or chemical combination of substances.

The various operations by which these objects are effected are described in works expressly devoted to pharmacy; and to these I must refer the reader for further information on this subject. A summary of them would be practically useless, while it would occupy space which can be advantageously employed with the consideration of topics which are strictly within the scope of the present work.

3. PHARMACODYNAMICS (*pharmacodynamica*, from φάρμακον, *a medicine*; and δύναμις, *power*;) is that department of Pharmacology which treats of the effects and uses of medicines.

This department of pharmacology is called *dynamical materia medica* (dynamische Arzneimittellehre) by Pfaff.

Pharmacology is either *general* or *special*.

DIV. I.—General Pharmacology.

General Pharmacology (*pharmacologia generalis*) treats of medicines generally.

The general pharmacological subjects which require examination may be conveniently considered in the following order:—

1. Modes of ascertaining the effects of medicines.
2. Active forces of medicines.
3. Changes which medicines undergo in the organism.
4. Physiological effects of medicines.
5. Therapeutical effects of medicines.
6. Parts to which medicines are applied.
7. Classification of medicines.

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[1] Cottereau, *Traité Elémentaire de Pharmacologie*, Paris, 1835.

[2] Goebel and Kunze, *Pharmaceutische Waarenkunde*, Eisenach, 1827—29.

[3] Guibourt, *Histoire Abrégée des Drogues Simples*, 3me éd. Paris, 1836.

[4] Pfaff, *op. cit.*

[5] Cottereau, *op. cit.*

[6] A. A. Da Silveira Pinto, *Codigo Pharmaceutico Lusitano, ou Tratado de Pharmaconomia*, Coimbra, 1835.

[7] For a notice of the ancient rhizotomist, see the *Historical Table*, art. *Greek Medicine.*

All these subjects belong to that department of pharmacology which may be termed *general pharmacodynamics*.

1. MODES OF ASCERTAINING THE EFFECTS OF MEDICINES.

Formerly the virtues of medicines were inferred from resemblances (fancied or real) in form, colour, &c. between these substances and parts of the organism. These marks or indications were called *signatures*, and were supposed to arise from astral influences[1].

There are four principal methods which, in modern times, have been resorted to for the purpose of determining the effects of medicines. These are founded, respectively, on—

1. The sensible qualities of medicines.
2. The natural-historical properties.
3. The chemical properties.
4. The dynamical properties.

1. THE SENSIBLE QUALITIES OF MEDICINES.—*Colour*, *taste*, and *odour* have been used to indicate, in a very general way, the medicinal properties of plants. But to all the general propositions which have hitherto been advanced concerning them, so many exceptions exist, that none possess much, if any, practical value.

It appears to me to be a waste of time and space to dwell on this subject; I beg, therefore, to refer the reader, for further information, to the writings of Linnæus[2], Cullen[3], and Edwards and Vavasseur[4]. In another part of this work, I shall have occasion to notice Mr. Greeves's classification of the articles of the Materia Medica according to their sensible qualities. In connection with this subject I may observe that some interesting information on the colour, odour, and taste of plants, is contained in Landgrebe's work on Light[5].

2. THE NATURAL-HISTORICAL PROPERTIES.—*Exterior form* and *structure* are made use of, in natural history, to determine the affinities of natural bodies: hence they are denominated *natural-historical properties*.

a. Minerals.—No conclusions, respecting the medicinal properties of minerals, can be deduced from crystalline form and structure.

Mr. Blake asserts[6], that the most striking points of resemblance exist generally between isomorphous compounds in their action on the animal tissues when *introduced into the blood*. Be this as it may, their action, when *taken into the stomach*, is often very dissimilar. Thus, the triphosphate of soda is isomorphous with the triarseniate of the same base; but no one will pretend to assert that their action on the system is alike. Arsenious acid is isomorphous with sesquioxide of antimony; yet their effects on the system are very dissimilar. Mr. Blake admits that the salts of lead and of silver are exceptions to his statement; their action on the pulmonary tissue being analogous, though they are not isomorphous.

β. Vegetables.—It has long been supposed, that those plants which resemble each other in their external appearances are endowed with analogous medicinal properties. Cæsalpinus was, according to Dierbach[7], the founder of this doctrine; though De Candolle[8] regards Camerarius as the first who clearly announced it. Linnæus[9] says, " Plantæ quæ *genere* conveniunt, etiam virtute conveniunt; quæ *ordine* naturali continentur, etiam virtute propius accedunt; quæque *classe* naturali congruunt, etiam viribus quodammodo congruunt." I may also refer to Isenflamm, Wilcke, Gmelin, Jussieu, and Barton, as other supporters of this opinion. But the most important writer in favour of it is De Candolle, who, in 1804, published the first edition of his work on this subject. In the year 1831, we had another interesting treatise on the same subject, by Dierbach. There are other writers, however, who deny altogether the possibility of judging of the virtues of plants by their exterior forms and botanical characters. Of these, it will be sufficient to mention Gleditsch[1].

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[1] See Sprengel, *Histoire de la Médecine*, t. iii. p. 321, Paris, 1815. Also, Schroder's *Compleat Chymical Dispensatory*, by Rowland, Lond. 1669.

[2] *Philosophia Botanica*, p. 283, ed. 4to. 1787.

[3] *A Treatise of the Materia Medica*, vol. i. p. 138, Edinb. 1789.

[4] *Manuel de Matière Médicale*, Paris, 1831.

[5] *Ueber das Licht*, Marburg, 1834.

[6] *Edinburgh Med. and Surg. Journ.* for July, 1841.

[7] *Abhandlung über die Arzneikräfte des Pflanzen, vergleichen mit ihrer Structur und ihren chemischen Bestandtheilen*, Lemgo, 1831.

[8] *Essai sur les Propriétés Médicales des Plantes*, p. 4, 2de éd. Paris, 1816.

[9] *Op. supra cit.* p. 278.

Vegetable substances owe their peculiar qualities to the structure, and consequent action, of the organs producing them; and, therefore, differences in the structure of an organ are attended with corresponding differences in the qualities of its products. It consequently follows, that the medicinal qualities of plants of the same natural order should be similar or analogous; and that they are so to a certain extent is fully ascertained by numerous facts: thus, if one vegetable species serve as nutriment for either animal or plant, we frequently observe that other species of the same genus, or even of a different genus, but of the same order, are also adapted for a like use; while, on the other hand, if any particular species be injurious, neighbouring species are likewise more or less so. Experience has fully proved, that in a very large number of instances there exists an analogy between the exterior forms and the medicinal properties of plants, so that we can sometimes predict the active principle and mode of operation of a vegetable, merely by knowing to what part of a natural arrangement it belongs. *Gramineæ*, *Melanthaceæ*, *Coniferæ*, *Labiatæ*, *Malvaceæ*, *Cruciferæ*, and *Ranunculaceæ*, are familiar illustrations of the accuracy of these observations.

There exist, however, many anomalies or exceptions to the statements now made. These are of two kinds:—

1st. Plants of the same natural order are frequently endowed with dissimilar medicinal properties.

The root and leaves of *Daucus Carota* are wholesome and nutritive; but the analogous parts of *Conium maculatum* are highly poisonous. Both of these plants, however, belong to the same natural order—UMBELLIFERÆ. In some cases we find plants even of the same genus differing considerably in their medicinal properties; as *Cucumis Melo* and *Cucumis Colocynthis*, of the order CUCURBITACEÆ. If we are to believe the statements of creditable writers, even GRAMINEÆ, which De Candolle declares to be "la famille la plus naturelle," contains more than one exception to the general statement in question. For the most part, the plants of this family are farinaceous and nutritive. "None," says Dr. Lindley[2], "are unwholesome in their natural state, with the single exception of *Lolium temulentum*, a common weed in many parts of England, the effects of which are undoubtedly deleterious, although perhaps much exaggerated." I may remark, however, that several other grasses have been asserted to be unwholesome. Loudon[3] tells us that the seeds of *Bromus mollis* bring on giddiness in the human species and quadrupeds, and are fatal to poultry. The root of *Bromus purgans* is said to be used in Canada as an emetic, in doses of forty grains. *Bromus catharticus*, a Chilian plant, has a thick root, which is stated to act as a purgative[4]. And Humboldt[5] informs us that *Festuca quadridentata* (fig. 6) is very poisonous, and even fatal to animals[6].

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[1] *De Methodo Botanicâ, dubio et fallaci virtutum in plantis indice.* Ed. 2nda, Lipsiæ, 1742.

[2] *Natural System*, 2d ed. 1836.

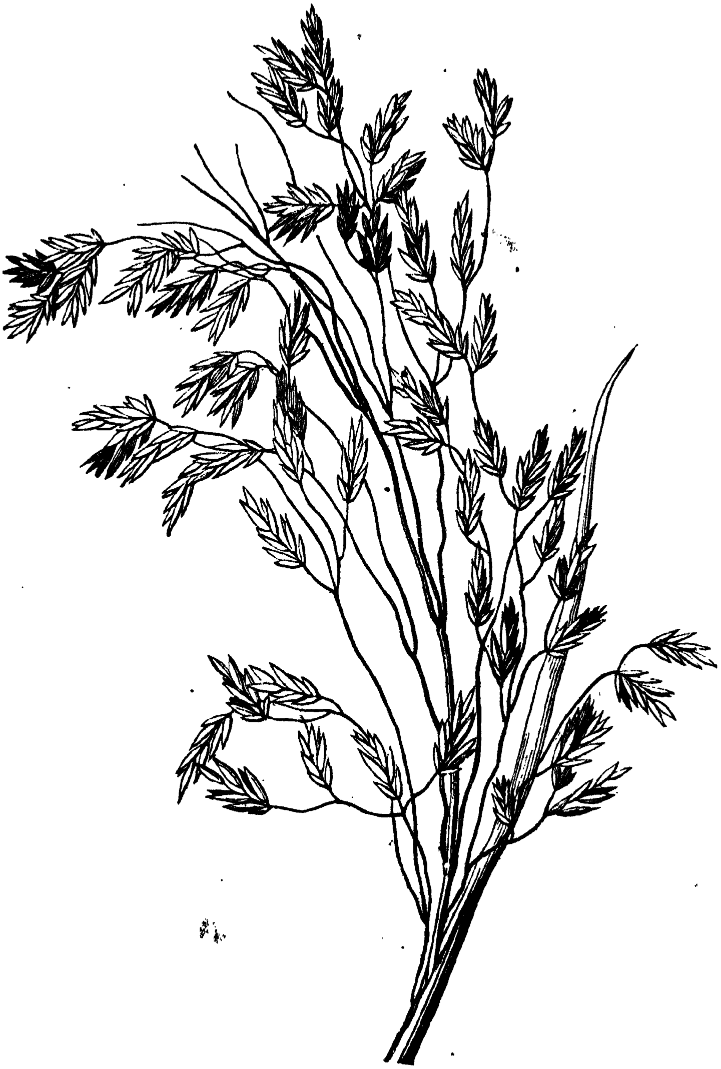
[3] *Encyclopædia of Plants*, p. 64.

[4] *Dictionn. de Matière Médic. par F. V. Merat et A. J. De Lens*, tom. i. p. 672.

[5] *Voyage*, t. i.

[6] Is this the grass described by some under the name of *Carapoucha*, and which by others has been called *Carapullo?* Frezier (*Voyage to the South Sea and along the Coasts of Chili and Peru*, in

FIG. 6.



Festuca quadridentata (Kunth).

years 1712, 1713, and 1714,) says, in speaking of Lima, "There is an herb called *Carapullo*, ich grows like a tuft of grass, and yields an ear, the decoction of which makes such as drink it lirious for some days. The Indians make use of it to discover the natural disposition of their chil- en. All the time when it has its operation, they place by them the tools of all such trades as they y follow,—as by a maiden, a spindle, wool, scissars, cloth, kitchen furniture, &c.; and by a youth, coutrements for a horse, awls, hammers, &c.: and that tool they take most fancy to in their delirium, a certain indication of the trade they are fittest for,—as I was assured by a French surgeon, who s an eye-witness of this verity." On this statement, Dr. Lindley (*Flora Medica*, p. 613, Lond. 38,) remarks, that it is uncertain whether the plant referred to be really of the order Gramineæ. cannot trace the name," he observes, "and the only Lima plant that I find bearing a name at like it, is Physalis pubescens, which, according to the *Flora Peruviana*, is there called *Capuli*."

In the family SOLANEÆ we meet with other exceptions, as in the fruit of *Capsicum annuum* and *Atropa Belladonna*. I might select many other instances to the same effect, but shall content myself with the examples already adduced, as sufficiently warranting the assertion that, in the present state of science, botanical affinities cannot be *confidently* relied on by the medical practitioner for determining the effects of remedial agents.

2dly. Plants of dissimilar structure are sometimes endowed with similar or very analogous medicinal properties.

An oleo-resinous juice, called turpentine, is obtained from *Pistachia Terebinthus*, a plant of the order TEREBINTHACEÆ, and a substance possessing almost identical properties, and bearing the same name, is procured from the genera *Pinus*, *Larix*, and *Abies*, of the order CONIFERÆ. Balsam of Copaiba, which agrees with the turpentines in all its leading properties, and whose constituents are actually isomeric with those of the turpentines, is procured from LEGUMINOSÆ. Yet the structure of Coniferæ is totally dissimilar to that of either Terebinthaceæ or Leguminosæ. Again, the effects of *Lobelia inflata*, a plant belonging to the order LOBELIACEÆ, are so analogous to those of *Nicotiana Tabacum*, which belongs to SOLANACEÆ, that the first-mentioned plant has received the name of Indian *Tobacco*. The term *Hellebore* (ἐλλέβορος) has been applied to two very different plants, viz. *Helleborus niger* and *Veratrum album*, in consequence, I presume, of an observed similarity of operation (both being drastic purgatives and narcotico-acrids); yet the first-mentioned plant is an exogen or dicotyledon, and belongs to the order RANUNCULACEÆ,—while the second is an endogen or monocotyledon, of the order MELANTHACEÆ.

γ. *Animals.*—No attempts have been made to trace a relation between the toxicological, medicinal or edible properties and the anatomical structure of animals. This has probably arisen from the comparatively small number of these beings which possess medicinal or poisonous properties; for we are enabled to employ, as food, animals of every class, from the highest to the lowest. Among quadrupeds and birds no species is poisonous[1], unless, indeed, the Arctic bear be an exception, whose liver is stated by Captain Scoresby[2] to be deleterious. Among fishes, mollusks, and insects, however, several species are hurtful; and it is frequently found that where one is deleterious, kindred species are likewise more or less so. Thus all the coleopterous insects belonging to the tribe *Cantharidiæ* of Latreille possess blistering properties.

3. THE CHEMICAL PROPERTIES of medicines have been sometimes resorted to for the purpose of determining the influence which these bodies have over the organism. For we sometimes find that substances possessed of similar chemical qualities operate in an analogous manner on the system. Thus sulphuric, nitric, and hydrochloric acids act very much alike; as do also potash and soda. But these analogies are not common; and we frequently meet with substances whose chemical properties are similar, but whose medicinal qualities are most incongruous, as in the case of quina and morphia: while, on the other hand, bodies whose chemical properties are exceedingly unlike, sometimes act in a very analogous manner; for example, manna and bitartrate of potash.

The properties of bodies are so completely altered by chemical combination, that it is, in most cases, difficult to form a correct opinion as to the action of a compound medicine, merely by knowing the nature and proportion of its constituent parts. The compounds of some of the metals, however, offer exceptions to this statement.

Mr. Blake[3] contends that a very close relation exists between the chemical properties and physiological effects.

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[1] Fleming's *Philosophy of Zoology*, vol. ii. p. 110, Edinb. 1822.

[2] *Account of the Arctic Regions*, vol. i. p. 520, Lond. 1820.

[3] *Proceedings of the Royal Society*, Jan. 28th, 1841.

4. THE DYNAMICAL PROPERTIES. *Observation of the effects caused by the application of medicines to the animal body.*—Some have examined the action of medicines on *dead* animal tissues, and drawn inferences therefrom as to the operation on the living organism. This mode of proceeding was adopted by Dr. Adair Crawford[1]. But it is admissible only for those remedies whose action is either physical or chemical.

The examination of the effects of medicines on *living* animals is a much more valuable and important mode of investigation; for it may be asserted, as a general rule, that a substance which is poisonous to one species is more or less so to all classes of animals; and, in a considerable number of instances, its action is of the same nature or quality, though usually very different in degree, and modified by the variations in the development of the several organs and functions. It has indeed been stated that many substances which are poisonous to man are innocuous to animals, and *vice versâ*. That this statement is wholly untrue, I will not venture to affirm, but I think that it is an exaggerated one; and I believe, with Dr. Christison[2], that "if the subject be studied more deeply, the greater number of the alleged diversities will prove rather apparent than real."

The principal differences observed in the operation of medicines on our domestic animals, and which depend on peculiarities of organisation and modes of sensibility, may be conveniently arranged under three heads, as follows:–

- α. Those relating to the nervous system.
- β. Those connected with the structure of the digestive organs.
- γ. Those relating to the skin.

α. To peculiarities in the organisation of the *nervous system* of different animals is to be referred the diversities observed in the operation of certain medicines on different animals. Thus opium, which in man usually produces sleep, sopor, or coma, generally produces convulsions in other animals, and, according to Charvet[3], "never coma, loss of consciousness, nor profound sleep." I have observed that the root of monkshood does not act precisely alike on rabbits and dogs. In the latter, one of the most remarkable symptoms of its operation is diminution of feeling; in the former, the function of feeling is much less obviously affected, but we observe more evident paralysis of the hind extremities and muscular weakness.

β. From differences in the structure of the *digestive organs* arise some peculiarities in the operation of medicines. In carnivorous animals, vomiting can be readily excited; whereas in herbivorous ones, as the horse and the rabbit, it is either not effected at all, or only with extreme difficulty. The rumen or paunch of ruminants possesses but little sensibility and few blood-vessels, and is very slightly affected by medicinal agents. Hence, in the administration of medicines to these animals, it is necessary to let them trickle slowly down so that they may flow along the œsophagean canal, and through the manyplics or third stomach, into the abomasum, or fourth or true stomach; and the late Mr. Youatt[4] ascribed the occasional inertness of ergot of rye on the ruminant to its being hastily poured from a large vessel, by which it falls into the paunch, and there remains inert. Lastly, it is remarkable that colocynth, jalap, gamboge, and bryony, which operate as violent purgatives on man and carnivorous animals, have comparatively little effect on the horse and other herbivorous animals[5].

γ. The *skin* also presents some peculiarities in the operation of medicines. Thus dogs are but little under the influence of sudorifics; while the skin of horses is exceedingly susceptible of the action of oil of turpentine.

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[1] *An Experimental Inquiry into the Effects of Tonics and other Medicinal Substances*, Lond. 1816.

[2] *Treatise on Poisons*, 4th ed. p. 73.

[3] *De l'Action comparée de l'Opium*, p. 164, Paris, 1826.

[4] See the article "*Ergot of Rye.*"

[5] Moiroud, *Pharmacologie Vétérinaire*, pp. 51, 269, and 274.

In ascertaining the action of remedial agents on the *human* body, it is necessary that we should examine their influence both in healthy and diseased conditions. For, by the first we learn the positive or actual power; while by the second, we see how that power is modified by the presence of disease. Moreover, in the latter condition we sometimes discover remedial influences which our knowledge of the effects of medicines on the healthy body could not have led us to anticipate. The beneficial operation of arsenious acid in agues, or in lepra, could never have been inferred from any experiments made with this substance in health merely; nor could we have formed a correct estimate of the effects and proper dose of opium by employing it in tetanus, nor by using mercurials in fever. The homœopathists assert, and with truth, that the study of the effects of medicines in the healthy state is the only way of ascertaining the *pure* or *pathogenetic* effects of medicines—since when we administer our remedies to invalids "the symptoms of the natural disease, then existing, mingling with those which the medicinal agents are capable of producing, the latter can rarely be distinguished with any clearness or precision[1]."

2. ACTIVE FORCES OF MEDICINES.

The production of effects, by the application of medicines to the living body, depends on the existence of two classes of powers or forces: the one residing in the medicine, and called the *active forces of medicines;* the other in the organism.

Bodies act on each other in one or more of three ways; viz. *physically,* by their weight, cohesion, external form, motion, &c.; *chemically,* by their mutual affinities; and *dynamically,* by agencies which are neither physical nor chemical merely. Hence we may examine the agencies of medicines under the three heads of physical, chemical, and dynamical.

1. PHYSICAL FORCES.—Alterations of cohesion, form, relative position, &c. are produced by physical forces. They are attended or followed by organic changes; and, therefore, a medicine whose action is simply physical produces two classes of effects—the one physical, the other vital; and the whole of its operation may be denominated *physico-vital.*

The *iatromechanical* or *iatromathematical* physicians explained the functions of the body, the production of diseases, and the operation of medicines, on mechanical principles. Thus stimulants were supposed to act by their pointed and needle-shaped particles, and emollients by their globular particles[2]. Locke[3] believed that the mechanical affections of medicines would explain the operation of these agents.

Several of the processes to which medicines are subjected before they are administered, have for their principal object the prevention or diminution of the mechanical influence of these agents. The hairs of the pods of *Mucuna pruriens,* quicksilver, and the agents termed demulcents act by their mechanical properties. Many substances act endosmotically (see p. 91).

2. CHEMICAL FORCES.—If substances, having powerful affinities for organic matter, be applied to the living tissues, they combine with the organic constituents, and act as *caustics* or *escharotics.* By the destruction of life in one

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Hahnemann's *Organon,* translated by C. H. Devrient, p. 190.
Sprengel, *Hist. de Médec.* by Jourdan, t. v. p. 131, et seq.
Essay concerning Human Understanding, book iv. chap. iii.

part, alterations of vital actions in neighbouring parts ensue; so that the action of caustics is attended by both chemical and vital effects; and the whole operation may be denominated a *chemico-vital process*.

By dilution, the energy of the affinity of caustics for organic matter may be so diminished, that they are incapable of destroying the life of the part, but merely disturb and alter the organic activity. This effect is termed *irritation*, and the agent inducing it is called an *irritant*. In this case the active force is still supposed to be affinity; that is, the particles of the caustic are presumed to have a tendency to unite with those of the organised tissues; but the union being resisted by the vital powers, a new action is set up, which constitutes the changes or effects before referred to. The long-continued application, however, of weak chemical agents will gradually effect slight changes in the composition of the tissues without producing the death of the altered parts; and these organic alterations are attended by the production of morbid actions.

Chemical changes are sometimes produced in the secretions of distant parts by the internal use of certain agents. Thus the qualities of the urine are modified by the administration of acids or alkalis; and as the modifications produced are precisely those which we might expect from the known chemical properties of these bodies, it is rational to infer that they are effected by chemical affinity.

Are the constitutional effects of acids, alkalis, metallic salts, &c. referable to chemical influences? We cannot deny the chemical power of these agents; but we are hardly authorised to ascribe the whole of their effects to it. The truth is, that the facts on which we are required to form our opinion are too few to enable us to draw any accurate or precise conclusions. We know that, by the internal use of madder, the bones and some other parts become coloured; and that the long-continued employment of the nitrate of silver occasionally gives rise to a deposit of silver under the skin; but with two or three exceptions of this kind, no chemical changes in the living tissues have been demonstrated.

Müller[1] ascribes the operation of most external agents to their chemical influence. "A great number of substances are important as medicaments, from producing a chemical change in the organic matter, of which the result is, not an immediate renovation of material and increase of vital force, but the removal of that state of combination of the elements which prevented healthy action, or excited diseased action; or the chemical change produced is such as to render the organ no longer sensible to a morbid stimulus; or it is such that certain apprehended destructive changes in its composition are no longer possible, as in the antiphlogistic plan of treatment; or, lastly, these substances produce a change in the nutritive fluids. Such substances are *alteratives*. By these remedies an organ morbidly changed in composition cannot be rendered sound by, as it were, a chemical process, but such a slight chemical change can be produced as shall render it possible for nature to restore the healthy constitution of the part by the process of nutrition."

The attempted explanation of the effects of medicines on chemical principles does not give a satisfactory explanation of the phenomena. How is it that the same remedy acts so unequally on different animals, on different individuals of the same species, and on the same individual at different periods? Why is the effect of opium greater on the child than on the adult? Are we to assume that the constituents of the brain of the young animal have more affinity for morphia than those of the brain of old animals?

The action of a medicine on one organ rather than on another is accounted for on the chemical hypothesis, by assuming the existence of unequal affinities of the medicinal agent for different tissues. Thus the action of alcohol on the brain is ascribed to the affinity of this liquid for the cerebral substance[1].

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[1] *Elements of Physiology*, by Baly, vol. i. p. 58, et seq.

3. DYNAMICAL FORCES.—Some substances exercise a most potent influence over the organism, without producing any obviously physical or chemical changes in the organic tissues. Such substances are said to act *dynamically.*

In the inorganic kingdom we have evidence of an influence which cannot be denominated either mechanical or chemical. The communication of magnetical and electrical properties to iron by mere contact with another body, without the production of any change of form or of composition, either of the iron itself or of the imparting body, is an example of this. Now, to influences of this kind the term *dynamical* has been applied; and several pharmacologists[2] have employed it to indicate those influences of medicines over the organism which are ascribable to neither mechanical nor chemical causes. As the term is a convenient one, I have adopted it.

Bischoff[3] regards the action of medicines on the organism as electrical, or, in some cases (as that of caustics), as electro-chemical.

In some few instances the effects of medicines are analogous to those of electricity. Thus the instantaneous death caused by hydrocyanic acid is somewhat like the effect of a stroke of lightning; and the convulsive paroxysm induced by touching an animal under the influence of strychnia or nux vomica is analogous to the effect of an electric shock.

3. CHANGES EFFECTED IN MEDICINES BY THE ACTION OF THE ORGANISM.

The changes which medicines suffer by the action of the organism are either physical or chemical, or both. They are effected by the mutual affinities which exist between the medicines or their parts and the substances with which they are brought in contact; and are modified by the temperature of the body, and by the relative proportions of the reacting bodies.

The rapidity with which volatile substances pervade the system and reappear in distant organs, must be greatly aided by the heat of the animal body. Sulphuric ether, for example, boils at 98° F.; that is, at the temperature of the blood; and the rapidity of its action is undoubtedly in part owing to its great volatility. Hydrocyanic acid, another swiftly-acting substance, boils at about 80° F.

The influence of quantity is illustrated in the case of alcohol. The non-coagulation of the blood by the absorption of rectified spirit from the stomach is to be ascribed to the influence of the mass of the blood; for a minute quantity of alcohol may be mixed with a large quantity of albumen without causing the coagulation of the latter.

The chemical changes which a medicine suffers in the part of the body with which it first comes in contact, are produced by the secretions of the part; or by the constituents of the living tissues; or, when it is injected into the blood-vessels, by the blood itself; or, when it is introduced into the alimentary canal, by the substances contained within this tube.

The secretions protect, to a certain extent, the living surface from the action of the medicinal agent. The protection is complete when the quantity of the medicine is small; it is incomplete when the quantity is large, and the energy of the affinities intense.

The precise nature of the changes which medicines undergo when they first come into contact with the body, have been carefully investigated in a very few instances only. For the greater number of medicines, accurate observations are entirely wanting; and we form our opinion of the nature of the changes principally by analogy, aided, in particular cases, by some isolated fact. Those which are best known are as follows:—

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[1] See Dr. Percy's *Experimental Inquiry concerning the Presence of Alcohol in the Ventricles of the Brain after Poisoning with that Liquid*, Lond. 1839.

[2] Burdach, *System der Arzneymittellehre*, Leipzig, 1807; C. H. E. Bischoff, *Die Lehre von den chemischen Heilmitteln.* Bonn, 1825; Vogt, *Lehrbuch der Pharmakodynamik*, 2td Aufl. Giessen, 1828.

[3] *Op. supra cit.* Bd. i. pp. 158, 162, and 163.

α. Some substances remain unchanged, and, being insoluble, are inert, or act mechanically; as *woody fibre*, which forms a leading constituent of all medicinal roots, barks, woods, fruits, and seeds. When these substances are swallowed, the woody fibre is evacuated with the fæces.

β. Some substances undergo no obvious chemical change, but, being liquid or soluble, mechanically mix with the fluids of the part to which they are applied, and become absorbed: as various *aqueous liquids*, holding in solution *colouring, odorous*, and other matters; *oil, alcohol, ether*, &c.

γ. Some substances undergo more or less chemical change by the action of acids, bases, salts, albumen, casein, ptyalin, pepsin, or other substances with which they come in contact; and the newly-formed body is, if soluble, absorbed, but not otherwise[1].

The *alkaline and earthy carbonates* are decomposed by the acids of the alimentary canal, with the evolution of carbonic acid.

Most of the *metallic oxides*, and the *metallic, alkaline*, and *earthy salts*, form new compounds with albumen, casein, &c.

Chalybeate preparations, when swallowed, are partly converted into sulphuret of iron, which darkens the fæces.

The *acids*, both inorganic and organic, combine with bases; and the salts which are thereby formed unite with organic matters.

Calomel yields a soluble mercurial compound.

The medicinal activity of a substance is sometimes greatly modified by the chemical changes thus effected in it.

Chemical antidotes are effective by rendering poisons insoluble.

Insoluble substances, by becoming soluble, acquire medicinal activity, as in the case of calomel.

Insoluble compounds formed in the blood by the action of medicinal agents injected into the blood-vessels, accumulate in the capillaries, and act there as mechanical irritants. Newly-formed soluble compounds, however, circulate with the blood.

Subsequent to their absorption, and while still within the system, medicines sometimes undergo various chemical changes. The reduction of the preparations of mercury and silver, and the deposition of these metals in the living tissues, are illustrative proofs.

Medicinal agents are ultimately expelled from the system by the excreting organs; and we can frequently detect them in the excretions; sometimes unchanged; at other times, more or less altered, or in combination with some other substance.

α. *Many salts*, as chlorate and nitrate of potash; *colouring matters*, as that of rhubarb; and various other substances, are found in the urine unchanged, or nearly so.

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[1] Since the above was in type some experiments, made by Oesterlen, have been published, which apparently prove the possibility of the absorption of insoluble substances (*Monthly Journal of Medical Science* for May 1847).

β. Some *odorous substances* are found in a somewhat altered state: thus oil of turpentine is found to have acquired a violet odour.

γ. Many substances are discharged from the system in combination with some other body: thus the *vegetable acids* are found in the urine in combination with bases.

δ. Other bodies are found in a more or less decomposed or altered state. The *alkaline salts which contain a vegetable acid* are converted into alkaline carbonates, which are found in the urine; and *benzoic acid* is converted into hippuric acid, which also occurs in the urine.

In some cases, the compounds found in the excretions may have been formed after their constituents were thrown out of the system. Thus the union of oxalic acid with lime, and the formation of octohedral crystals of oxalate of lime, must have taken place after the oxalic acid was secreted by the kidney.

4. PHYSIOLOGICAL EFFECTS OF MEDICINES.

The effects which medicines are capable of producing in healthy individuals, are denominated *primary, immediate,* or *physiological.*

Formerly no distinction was made between the effects which medicines produce in health, and those which they give rise to in disease; and the terms *virtues, properties, faculties,* and *powers,* were applied to both classes of effects. But Bichat, and subsequently Barbier and Schwilgué, pointed out the propriety of considering them separately.

By the term *effects* are meant the symptoms or perceptible alterations produced by medicines in the aspect or functions of organs. They are of two kinds: those which arise from the direct action of medicines, and those which result from the reaction of the organism.

Thus the concentrated mineral acids and alkalies decompose the tissues of both living and dead bodies by uniting with some of their constituents, and thereby produce certain chemical alterations which we denominate the effects of the action of these agents. In the living body, inflammation is set up in the tissue surrounding the cauterised part; and the vital alterations which are in consequence induced are called the effects of the reaction of the organism.

The action of medicines depends on their active forces already noticed: the reaction of the organism on the vital force.

In many instances, the nature of the action of medicines is unknown, as in the case of aconitina, strychnia, and the acrid volatile oils and resins. For these agents are without any obvious influence on the dead body; and the effects which they give rise to when they are applied to the living body are referable to the reaction of the organism.

1. *Nature or Quality of the Physiological Effects.*

The physiological effects of medicines may be—

1. Physico-vital,
2. Chemico-vital, or
3. Purely vital.

A medicine whose action is either physical or chemical, gives rise to vital changes by exciting the reaction of the organism, and thus its total effects are neither purely physical nor purely chemical, but physico-vital or chemico-vital.

The effects of some medicines are purely vital: at least, neither physical nor chemical changes are perceptible.

It will be convenient to consider separately the physical, chemical, and vital effects.

1. PHYSICAL EFFECTS.—The physical influences of medicines deserve to be more carefully investigated than they have hitherto been, as they are probably much more important than is usually supposed.

a. Some medicines act by their external form and weight.—Thus quicksilver, when swallowed to the extent of several ounces, operates by its weight on the bowels; and woody fibre, the hairs of *Mucuna pruriens*, silica, glass, and other substances which undergo little or no change in the alimentary canal, act as foreign bodies by their external form and weight.

β. Many medicines produce physical effects on the body by their influence over the phenomena of endosmose and exosmose.

When the serum of the blood is separated from another liquid by an organic membrane, two currents are in general established through the membrane; one from the serum to the solution, the other from the solution to the serum. When the intensity of the first exceeds that of the second, it is called *endosmose of the serum*; but when the intensity of the second exceeds that of the first, it is termed *endosmose of the solution*[1]. In some few cases, presently to be noticed, this double current or mutual permeation does not take place.

1. *Substances which undergo endosmose and exosmose with the serum of the blood.*—The kind of endosmotic influence which these bodies exercise varies, in many cases, with the degree of concentration of the solutions. Very concentrated solutions in general cause endosmose of the serum; whereas dilute solutions have a reverse effect, and give rise to endosmose of the solution; and for solutions of a certain intermediate strength, the two currents are equal.

a. Substances which cause endosmose of the serum.—This division includes concentrated solutions of various salts (phosphate of soda, nitrate of potash, chloride of sodium, iodide of potassium, tartrate of potash, sulphates of soda and potash, phosphate of potash, and alum), native seidlitz water, Pullna water, sufficiently concentrated solutions of certain vegetable purgatives (manna, and the extracts of senna, rhubarb, the herb mercury, tamarinds, cassia, colocynth and aloes, resins of scammony and jalap, and castor oil), of various narcotic substances (one part of the alcoholic extract of the following substances to five parts of water: black hellebore, hemlock, henbane, aconite, and belladonna), solution of cane sugar (this causes a very powerful current), dilute spirit, and a solution of cantharidin in olive oil (prepared by digesting one part of powdered cantharides in two and a half parts of oil at 176° F.)

β. Substances which cause endosmose of the solution.—This division includes water (which produces the strongest current), dilute solutions of salts (phosphate of soda, nitrate of potash, chloride of sodium, and iodide of potassium), solutions of certain acids (acetic, tartaric, citric, and sulphuric acids), of ammonia, of nitrate of strychnia, and of sulphate of quina, hydrocyanic acid, laurel water, and certain non-purgative mineral waters (viz. those of Passy, Spa, Vichy, Plombières, Cauteretz, Mont d'Or, &c.)

2. *Substances which do not undergo endosmose and exosmose with the serum of the blood.*—These may be arranged in two divisions:—

a. Substances which penetrate the membrane and render it unfit for endosmose.—To this division belong the solution of sulphuretted hydrogen and decoction of tobacco. Under the influence of either of these liquids, the membrane becomes permeable and yields to that liquid which exercises the greatest amount of pressure β. *Substances whose presence puts a stop to the phenomena of endosmose, and renders the membrane impermeable to either liquid.*—To this division belongs the solution of hydrochlorate of morphia.

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[1] Poiseuille, *Comptes rendus*, t. xix. p. 944, 1844.

The endosmotic influence of medicines may be exercised when they are applied to the body, and before they become absorbed, as well as after their absorption into the blood. In the first case, it is exerted through the coats of the vessels on the blood; in the second case, it is exercised either through the membrane of the blood corpuscles on the fluid contained within them, or through the coats of the capillaries on the parenchyma of organs.

As absorption and nutrition are phenomena of endosmose, it is obvious that the endosmotic influence of medicines, by modifying these functions, must greatly contribute to the production of the effects of medicinal agents; though, in the present state of our knowledge, it is not possible to state precisely the exact share which this influence has in the production of the effects. The following, however, are a few illustrations of the attempted application of the endosmotic influence of medicines to the explanation of their physiological effects.

1. Substances which, when introduced into the alimentary canal, produce endosmose of the serum usually act as purgatives; for example, concentrated saline solutions, solutions of cathartic extracts, &c. Poiseuille found, after the use of saline purgatives, a considerable quantity of albumen in the alvine excretion. All substances, however, which produce endosmose of the serum are not purgatives,—as solution of cane sugar. Poiseuille ascribes this to the conversion of the sugar into lactic acid, which, like several other vegetable acids, causes endosmose of the solution.

2. While saline solutions whose specific gravity is greater than that of the serum of the blood (1·027 to 1·029) produce endosmose of the serum and consequent purgation, weak saline solutions whose specific gravity is less than that of the serum of the blood produce endosmose of the solution[1]; and when introduced into the alimentary canal, they become speedily absorbed, and, by their action on the kidneys, excite diuresis. Hence the necessity of administering solutions which are intended to reach the kidneys in a dilute form, and of a lower density than that of the serum of the blood.

3. A solution of hydrochlorate of morphia added to a saline solution, first checks, then entirely stops, the endosmose of the serum, and afterwards reverses the current, and produces endosmose of the solution. The efficacy of morphia and opium in checking the purgative effects of other substances, and in causing constipation, has been ascribed by Poiseuille to this endosmotic influence.

4. Dr. G. O. Rees[2] has shewn that agents which alter the specific gravity of the serum of the blood exert an influence on the blood-corpuscles by affecting the endosmotic currents through their membranes: agents which increase the specific gravity of the serum collapse the corpuscles, while those which lessen the specific gravity distend them. Water injected into the jugular vein of the dog caused rapid distension of the corpuscles, and rupture of their membrane.

But alterations in the specific gravity of the serum are produced not merely by substances added to the blood, but by agents which influence the action of the secreting organs. Thus hydragogues, diuretics, and sudorifics, by removing water from the system, increase the specific gravity of the serum, and thus indirectly give rise to physical alteration of the blood-corpuscles.

Alterations in the specific gravity of the serum, and of the condition of the blood-corpuscles, are probably attended with important effects in the animal economy. Thus, Dr. Rees observes that, when the corpuscles are enlarged by distension, they are precluded the possibility of entering tubes of the same calibre as before, and thus they may exert a mechanical plugging action on the mouths of bleeding vessels. Moreover, when their contents are more dilute than usual, their endosmotic action on the chyle is lessened, and thus "genesis and the nutrition of the corpuscles is interfered with, and is totally deranged."

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[1] Liebig, *Lancet*, June 8th, 1844.

[2] *London Medical Gazette*, New Series, vol. i. for the Session 1844-5, pp. 753, 836, and 849. Also, *Guy's Hospital Reports*, Oct. 1841, p. 379; and 1842, p. 317.

The effects of medicines on the blood-corpuscles have been particularly noticed by Schultz[1]; but he ascribes the effects to alterations in the vital condition of the corpuscles.

5. The particles of medicinal substances, while contained in the blood, may, perhaps, exercise their endosmotic influence on the parenchyma of organs through the coats of the capillary vessels; and by more or less modifying the phenomena of endosmose and exosmose, by which, in the state of health, the nutrition and repair of organs are effected, must produce important effects in the animal economy. Alcohol in the blood, says Poiseuille, tends to produce depletion of organs to the gain of the sanguineous mass. Do the phenomena of drunkenness depend on this effect, or rather do they result from this effect and the peculiar action of alcohol penetrating our tissues? Water and ammonia, which, says Poiseuille, relieve drunkenness, may, perhaps, do so by producing an effect opposite to that of alcohol. He also suggests that the deleterious action of hydrochlorate of morphia may depend on its opposing the phenomena of endosmose and exosmose which, in the normal state, are continually going on in the interior of organs. Furthermore, he does not think it improbable that the poisonous effects of sulphuretted hydrogen may be due to the opposition which this agent makes to the ulterior phenomena of endosmose and exosmose in organs.

The endosmotic currents going on through a membrane between two liquids, lessen, and ultimately stop, owing to the membrane becoming saturated with the liquids which moisten it. But, by displacing the liquid layers in contact with it by agitation, or by substituting other kinds of liquids, the currents proceed again actively. Founded on this fact, Poiseuille suggests that the *tolerance* of remedies, on which so much stress has been laid by the Italian schools, may be due to the contact of the same substance with the membranes of the digestive tube, which, in consequence, becomes unfitted for transmitting the same quantity of fluid into the blood.

2. CHEMICAL EFFECTS.—In consequence of the mutual affinities which exist between some medicines and the constituents of the tissues and of the blood, numerous and important chemical effects are produced in the animal economy. The *halogenous bodies*, some of the *combustible metalloids*, the *acids*, the *alkalies*, *metallic salts*, *tannin*, *creasote*, and *alcohol*, act in this way.

a. The *halogenous bodies* (chlorine, bromine, and iodine,) abstract hydrogen and unite with bases. Indirectly they sometimes become oxidizers by taking hydrogen from water and setting free the oxygen. In some cases they may, perhaps, combine directly with organic substances.

Iodine, when applied to the epidermis, produces a brown stain owing to the formation of ioduretted hydriodic acid. After its internal use, it is found in the urine in the form of hydriodic acid and iodide; and perhaps in that of iodate also[2].

The antiseptic and disinfecting properties of the halogenous bodies depend probably on some of the chemical actions above alluded to.

β. The *non-metallic combustibles* (sulphur and phosphorus) combine with both oxygen and hydrogen.

Sulphur, taken into the stomach, is thrown out of the system in the urine in the form of sulphuric acid and sulphuretted hydrogen.

Phosphorus is thrown out of the system in the form of phosphorous acid, and, perhaps, also as phosphoric acid and phosphuretted hydrogen.

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[1] *Natürliches System der allgemeinen Pharmakologie nach dem Wirkungsorganismus der Arzneien.* Von Dr. C. H. Schultz Schultzenstein, 1846.

[2] Dr. G. O. Rees *On the Analysis of the Blood and Urine*, 2d ed. 1845, p. 82.

γ. The *acids* (sulphuric, nitric, hydrochloric, phosphoric, and acetic,) combine with bases, decompose many salts, and unite with or decompose the organic constituents of the body.

The very dilute acids form, with albumen and fibrine, compounds which are insoluble when an excess of acid is present. To this statement acetic and phosphoric acids are exceptions, as their compounds with albumen and fibrine are very soluble.

The concentrated mineral acids decompose most organic compounds. Some of them act as oxidizers. The yellow stain which nitric acid produces with organic tissues depends on the formation of xantho-proteic acid.

The acids are absorbed into the blood, and are thrown out of the system by the excreting organs, especially by the kidneys, the secretions of which they render preternaturally acid. But, during their passage through the system, they are in combination, and have their acid properties neutralized; for the blood does not lose its alkaline properties by transmitting them; and, in the urine, the acids are found, in part at least, in combination.

δ. The *alkalies* unite with acids, decompose some salts, and combine with or decompose the organic constituents of the body.

They decompose albumen and fibrine, but, unlike most of the acids, they form soluble compounds with these organic substances.

Like the acids, the alkalies enter into combination, are absorbed into the blood, and are thrown out of the system by the excreting organs, especially by the kidneys, the secretions of which they render alkaline. The continued use of alkaline substances sometimes leads to the deposition of the earthy phosphates in the urine.

Alkalies promote the passage of fatty matters into the system by forming with them an emulsion, which readily passes through animal membrane.

ε. *Metallic salts.*—Most metallic salts react chemically on the organic tissues, and give rise to the formation of new compounds.

The precise chemical changes produced by the metallic salts in the organic tissues have not been very clearly ascertained. They are presumed to be similar to those produced by the action of the metallic salts on albumen.

A considerable number of these salts occasion, when added to albuminous liquors, precipitates which are soluble in many saline solutions, and frequently also in an excess of the albuminous liquor. These precipitates consist of an organic substance (albumen), and metallic matter (oxide or salt); and are called *metallic albuminates*. In some cases, they appear to be mixtures of two substances; one a compound of albumen with the acid of the salt; the other a compound of albumen with the metallic oxide. Sulphate of copper, nitrate of silver, bichloride of mercury, acetate of lead, and chloride of zinc, are salts to which the preceding remarks are applicable.

Most of the metallic salts also combine chemically with solid albumen and fibrine.

The alkaline and earthy salts react chemically on the organic tissues; but the precise changes which they produce have been scarcely investigated.

ζ. *Tannic and gallic acids.*—Tannic acid, in the impure state called tannin, acts on the animal tissues in virtue of its affinity for their constituents. It forms, with albumen and gelatine, compounds which are insoluble in water; and it also combines with fibrine. When taken into the stomach, it unites with the constituents of the epithelium, and of the mucous membrane of the alimentary canal. It becomes absorbed, and is evacuated from the system in the urine.

The state of combination in which tannic acid exists in the blood, and in the urine, has not been ascertained.

Gallic acid, when taken into the stomach, becomes absorbed, and is evacuated from the system in the urine; but the nature of its chemical action on the organism is unknown. Unlike tannic acid, it does not form with gelatine a compound insoluble in water.

η. *Creasote, alcohol, and ether.*—Both creasote and alcohol cause the coagulation of albumen.

Creasote causes the coagulation of the albumen both of the egg and of the serum of the blood; and decomposes the epidermis, the epithelium, and other albuminous tissues. Its chemical influence over animal tissues is further evinced by its powerful antiseptic properties.

The action of alcohol on the albuminous and fibrinous tissues consists essentially in the abstraction of water from them. Hence, the more the alcohol is diluted with water, the feebler is its chemical influence.

Ether is closely related to alcohol. It coagulates the albumen of the egg, but not the albumen of the serum of the blood.

3. VITAL EFFECTS.—The vital effects of medicines are frequently, though not invariably, preceded or accompanied by appreciable physical and chemical changes.

Medicinal agents may either destroy life or modify vital action: in the former case they become poisons.

Agents which destroy life may also effect the complete destruction of the parts with which they come in contact, as in the case of the substances called corrosives. They produce at the same time *morpholysis* and *biolysis*[1]; that is, they destroy both organisation and life.

Liebig[2] refuses to call these substances poisons. They merely destroy, he says, the continuity of particular organs, and are comparable, in their operation, to a heated iron or a sharp knife.

The modifications in the vital manifestations of the system produced by medicines are of three kinds: augmentation, diminution, and alteration of vital action.

Müller[3] observes that, viewing medicinal substances generally, there can be but three principal modes of action and three classes of agents; viz. *stimulants*, *alteratives*, and *agents destroying organic composition.*

Schultz[4] thinks that all the organic effects of medicines may be referred to three kinds of actions; viz. the *anabiotic*, the *biolytic*, and the *agonistic*[5]. The first have an organising tendency, and promote strength: they are produced by wines, tonics, aromatics, &c. The second have a disorganising tendency, and lessen or destroy strength; they are caused by acids, salts, metallic substances, and narcotics. The third are defensive against medicines and diseases which they endeavour to expel from the system; they are induced by acrids and evacuants.

1. Agents which heighten, augment, or increase vital action are called *stimulants* or *excitants*. Some of them exercise a renovating or restorative influence, and are essential to life. They are the *vivifying* or *vital stimuli* (see p. 8, footnote). Others, though not essentially renovating, yet, under certain conditions, exert a local, vivifying, and strengthening influence. These are called by Müller[6] *homogeneous stimuli*. They are the true tonics. "They exert a vivifying influence when their action on the organic matter favours the production of the natural composition of the parts." Lastly, others have no renovating or vivifying influence; and their continued action on the body is followed by exhaustion. These are termed by Müller *heterogeneous stimuli*.

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[1] C. H. Schultz, *Natürliches System der allgemeinen Pharmakologie*, Berlin, 1846, p. 117.

[2] *Organic Chemistry in its Application to Agriculture and Physiology*, edited by Lyon Playfair, Ph.D. London, 1840.

[3] *Physiology*, translated by Baly, vol. i. p. 57.

[4] *Op. supra cit.*

[5] *Anabiotic*, from ἀναβιόω, to revive; *biolytic*, from βίος, life; and λύω, to loosen or unbind: *agonistic* (ἀγωνιστικὸς), from ἀγών, a combat or conflict.

[6] *Physiology*, translated by Baly, vol. i. p. 59.

2. Agents which directly lower or lessen excitability are termed *sedatives* or *contra-stimulants*. Cold is the most unequivocal sedative.

3. Agents which are neither mere stimulants nor mere sedatives, but which effect some alteration in the nature or quality of vital action (probably by producing some change in the composition of the organic tissues), are called *alterants* or *alteratives*. Nearly the whole of the articles comprising the materia medica belong to this group. This alterative action of medicines appears to have been entirely overlooked both by the founder of the *Brunonian theory* and the supporters of the *doctrine of contra-stimulus*.

α. Brunonian Theory.

Dr. John Brown[1] assumed that man and other animals possess a peculiar property, termed *excitability*, by which they are distinguished from inanimate bodies. The agents which support life he termed *exciting powers;* and these, acting upon the *excitability*, maintain life; in the language of Brown, they produce the effect called *excitement*. The exciting powers, being stimulant in their nature, are called *stimuli*. They are of two kinds: universal and local. When they are in due proportion, *health* is produced: when they act with too great energy, they exhaust the excitability, and cause *indirect debility:* when with too little, they produce *direct debility*.

Diseases arise from either excessive or deficient excitement: in the first case they are called *sthenic;* in the second, *asthenic*. Remedies are stimuli; some acting with more, others with less, energy than is suited to health: the former are fitted for asthenic diseases, and are called *stimulant* or *sthenic* remedies (*e. g.* animal food, caloric, wine, spirit, musk, ammonia, camphor, and opium); the latter for sthenic diseases, and are called *debilitating* or *anti-sthenic* (*e. g.* bleeding, cold, low diet, vomiting, purging, sweating, and rest).

According to this doctrine, all medicines are stimuli, and differ from each other in the degree in which they exert their stimulant power: moreover, they are supposed to cause exhaustion by producing previous over-excitement.

Considered in a therapeutical point of view merely, the following objections present themselves to this theory:—

1. Many agents produce exhaustion without previously occasioning any obvious over-excitement (as the respiration of sulphuretted hydrogen or hydrocyanic acid gases).

2. Medicines differ from each other in something more than the degree of their power. If we compare together the effects of foxglove, ammonia, hydrocyanic acid, cinchona, mercury, alcohol, elaterium, and opium, the truth of this remark will be obvious.

3. The great majority of medicines act neither as stimulants nor sedatives merely; they alter the quality of the vital actions: and this alterative effect has been quite overlooked by the Brunonians.

β. Doctrine of Contra-stimulus.

(New Italian Doctrine.)

This doctrine is a modification of the preceding. It was advanced about the commencement of the present century by Rasori and Borda, and was subsequently adopted by Tommasini and some other distinguished Italian physicians.

It admits two classes of medicines: the one called *stimulants* or *hyper-*

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[1] *The Works of Dr. John Brown*, by Dr. W. C. Brown, Lond. 1804.

sthenics; the other, *contra-stimulants* or *hyposthenics*. The first exalt, the second depress, the vital energies. Hence this doctrine obviates one of the objections to the hypothesis of Brown, since it admits the existence of agents possessing a positive power of reducing vital action.

Contra-stimulants obviate or counteract the effects of stimulants. Thus wine being universally admitted to be a stimulant, those agents, which relieve the inebriation produced by it, are denominated contra-stimulants. Reasoning thus, the supporters of this doctrine deny that purgatives stimulate the stomach or intestines; for though they evacuate the contents of the alimentary canal, yet their general effects are depressing. If it be objected, that their continued use causes inflammation, it is answered that the same effect is produced by the most powerful contra-stimulant—cold; and they account for it by ascribing it to reaction, which, though a consequence of contra-stimulus, is not directly caused by it. But, by the same process of reasoning, it would not be difficult to show that some of the substances which the Italian physicians denominate stimulants (as opium) are really contra-stimulants, since they are frequently useful in relieving excitement. Indeed, the supporters of this doctrine are by no means agreed among themselves as to the stimulant or contra-stimulant quality of certain medicines; for some of them regard cinchona as belonging to the class of stimulants, while others rank it among the contra-stimulants.

It will be obvious, from the preceding remarks, that the supporters of the doctrine of contra-stimulants disregard, or overlook, the physiological effects of medicines, and direct their sole attention to the secondary effects or consequences, which are uncertain, and often accidental: for many of the agents denominated contra-stimulants do not always, or even frequently, relieve excitement, but often have the contrary effect. The founders of this doctrine, therefore, have assembled under the same head substances causing the most dissimilar and opposite effects; while they have separated others whose general operation is very analogous. They assume the existence of certain diseases, which they call sthenic, because they are produced by too much stimulus, and admit the existence of contra-stimulants, because certain agents sometimes, or frequently, relieve this state. In other words, they judge of the nature of a disease by the effect of the curative means, and of the virtues of medicines by the nature of diseases. So that if a disease, now supposed to be sthenic, should hereafter prove to be asthenic, the medicines used to relieve it would immediately pass from the class of contra-stimulants to that of stimulants!

But the most important objection to the doctrine of contra-stimulus is, that its supporters have totally overlooked that alterative action which nine-tenths of the most important articles of the materia medica evince. When we attentively watch the effects of medicines, it will become manifest that few of them excite or depress merely. Their most characteristic property is that of changing or altering the quality of vital action; and, among the more active of our medicinal agents, scarcely two agree in producing the same kind of alteration. This objection to the doctrine of contra-stimulus equally applies to the doctrine of Brown; and appears to me to be fatal to both hypotheses.

The supporters of the doctrine of contra-stimulus assert that the doses of contra-stimulants should be proportioned to the degree of excitement; and that, when inflammatory action runs high, the patient can bear very large doses without any obvious evacuation, the disease being subdued wholly by the contra-stimulant effect upon the solids of the body. This asserted capability of bearing increased doses has been denominated *tolerance*[1] of medicines; and has led to the employment of remedies in much larger doses, and at shorter intervals, than were previously ventured on; and, in the case of emetic tartar, the practice has proved highly successful. But, if the hypothesis were true, the tolerance ought to decrease as the disease declines, which certainly does not hold good with respect to emetic tartar, as will be hereafter mentioned. The truth appears to be, then, that many medicinal substances may be administered with safety, and, in certain maladies, with advantage, in doses which were formerly unheard of; and for this fact we are indebted to the founders of the doctrine of contra-stimulus[2].

In some maladies, as congestion or inflammation of the brain, large quantities of blood may be abstracted without causing syncope, and not only with impunity, but with benefit. These diseases, therefore, appear to confer a protective influence. On the other hand, in fever, intestinal irritation, dyspepsia, and cholera, the abstraction of a much smaller quantity of blood is attended with syncope; so that these maladies appear to diminish the tolerance of blood-letting. Dr. Marshall Hall has laid great stress on these facts[3], and has proposed to employ blood-letting as a diagnostic to distinguish irritation from inflammation. Thus when we are doubtful whether a disease is encephalitis or intestinal irritation, he says "we must prepare the arm, open a vein, and then place the patient upright, and let the blood flow until the lips become pallid; if the case be encephalitis, an extreme quantity of blood will flow, even thirty or forty ounces, or more, before there is any appearance of syncope; if it be intestinal irritation, syncope occurs before one-fourth of that quantity of blood has left the circulating system[4]."

Thus assuming *the degree of tolerance in blood-letting in health* to be ℥xv., he says the *augmented tolerance* in congestion of the brain will be ℥xl.—l.; in inflammation of the serous and synovial membranes, ℥xxx.—xl.; in inflammation of the parenchyma of organs, ℥xxx.; and in inflammation of the skin and mucous membranes, ℥xvj. The *diminished tolerance* in fevers and eruptive fevers he fixes at ℥xij.—xiv.; in delirium tremens and puerperal delirium, at ℥x.—xij.; in laceration or concussion of the brain, and in intestinal irritation, at ℥viij.—x.; in dyspepsia and chlorosis, at ℥viij.; and in cholera, at ℥vj.[5]

But though I admit the general fact that some diseases augment while others lessen the tolerance of blood-letting, yet I am by no means prepared to admit all the inferences which Dr. Hall has drawn therefrom. The distinction which he sometimes makes between irritation and inflammation is oftentimes more ideal than real; as when he endeavours to shew that the pleurisy caused by broken ribs is rather irritation than inflammation[6]. And, moreover, while we may fairly doubt whether blood-letting is capable of distinguishing inflammation from irritation, the propriety of resorting to so powerful an agent in doubtful cases is fairly questionable, and sometimes highly dangerous. "In my opinion," observes my friend Dr. Billing, "before such a decided step is adopted, the physician ought to have made up his mind as to what is the nature of the disease[1]."

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[1] See p. 93, for a notice of Poiseuille's explanation of the cause of the tolerance of medicines.

[2] For further information respecting the doctrine of contra-stimulus, see *Della Nova Dottrina Medica Italiana. Prolusione alle Lezioni di clinica medica per l'Anno scolastico* 1816-1817, del Professore Tommasini, Firenze, 1817; *Quarterly Journal of Foreign and British Medicine and Surgery*, vol. iv. p. 213, Lond. 1822; *The Edinburgh Medical and Surgical Journal*, vol. xviii. p. 606; and the *Lancet*, vol. ii. for 1837-38, pp. 696, 770, and 862.

[3] *Researches principally relative to the Morbid and Curative Effects of Loss of Blood*, 1830.

[4] *On the Diseases and Derangements of the Nervous System*, p. 352, Lond. 1841.

[5] *Introductory Lecture to a Course of Lecteres on the Practice of Physic, delivered at the Medical School in Aldersgate Street*, p. 42, London [1834].

[6] *Lancet*, Nov. 4, 1837; and *Principles of Diagnosis, and of the Theory and Practice of Medicine*, p. 355, Lond. 1837.

2. *Locality or Seat of the Physiological Effects.*

The physiological effects of medicines take place either in the part to which these agents are applied, or in more or less distant parts. The former are called *local* or *topical effects*; the latter, *remote effects*.

1. LOCAL OR TOPICAL EFFECTS.—Physical, chemical, and vital changes are produced by the topical action of medicines.

Particular medicines appear to act primarily on particular tissues: thus, narcotics on the nerves of the part, acrids or irritants on the capillary blood-vessels, and so on. But an alteration in the condition of one tissue is in general attended with some change in the state of other tissues; and thus agents whose primary action is on the nerves may secondarily affect the capillaries, and, *vice versâ*, those whose influence is first directed to the capillaries may indirectly affect the nerves.

2. REMOTE EFFECTS.—These, like local effects, include physical, chemical, and vital changes.

Of the various remote effects it cannot be doubted that some are the consequences of others: in other words, some are primary or direct, others secondary or indirect. But so close and intimate are the relations which exist between the different organs and functions, that it is frequently difficult, and sometimes perhaps impossible, to distinguish the primary and secondary effects from each other; and it is not improbable that many of the effects now regarded as primary or direct are, in reality, secondary or indirect. This difficulty is well illustrated in the case of the narcotics whose operation on the nervous system is usually considered to be primary or direct, but which C. H. Schultz[2] considers to be a consequence of a previous change effected in the blood-corpuscles. "Narcotics," he observes, "paralyse the blood-corpuscles, and by these the effect is communicated to the nervous system."

It has been hitherto generally supposed that there were two media by which medicines or poisons affected remote parts: these were, *absorption*, or the passage of medicinal or poisonous molecules into the blood; and *sympathy*, or by an impression transmitted through the nerves.

Sir Benjamin Brodie[3] inferred this double mode of operation from his experiments on several poisons. But it has appeared to some writers improbable that an agent should be capable of affecting remote parts in two ways. "All fair analogy," observe Messrs. Morgan and Addison[4], "forbids the conclusion that a poison or an ordinary cause of disease shall at one time produce constitutional disturbance through the medium of one system of organs, and at another time through the medium of another system of organs." Difficulties, however, have hitherto appeared in the way of an exclusive assumption of either mode of operation; and, therefore, while Magendie, on the one hand, advocated the operation by absorption, and Messrs. Morgan and Addison, on the other hand, that by sympathy, most writers, dissatisfied with these exclusive views, have adopted Sir Benjamin Brodie's opinion. Although late investigations strongly favour, if, indeed, they do not absolutely establish, the correctness of Magendie's opinion, I think it expedient, so long as any doubt remains, to examine both views.

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[1] *First Principles of Medicine*, p. 67, foot-note, 4th edit. Lond. 1841.

[2] *Natürliches System der allgemeinen Pharmakologie*, p. 172, Berlin, 1846.

[3] *Phil. Trans.* for 1811, p. 178; and for 1812, p. 205.

[4] *An Essay on the Operation of Poisonous Agents on the Living Body*, p. 14, Lond. 1829.

Mechanical violence, corrosives, the sudden impulse of light, heat, cold, electricity, &c. which "operate physically and on the nervous system[1]," are, strictly speaking, neither medicines nor poisons, and, therefore, are excluded from our present inquiry.

3. *Absorption of Medicines.*

Proofs.—The operation of medicines and poisons by absorption is proved by the following facts:—

1. The disappearance of the medicine or poison from the part to which it was applied.
2. Its detection in a remote part.
   - *a.* In the blood and chyle.
   - *β.* In the animal solids.
   - *γ.* In the excretions.
3. The prevention of its remote effects by the prevention of its circulation.
4. The promotion or retardation of its remote effects by the promotion or retardation of its circulation.
5. The similarity of remote and topical effects.
6. The medicinal or poisonous quality communicated to the animal solids and fluids.
7. The occurrence of remote effects after the division of the spinal cord, or of all parts except the blood-vessels.
8. The production of the remote effects by injection of a medicine or poison into the blood.

1. *Disappearance of medicines and poisons from the parts to which they are applied.*—Medicinal and poisonous substances disappear from the alimentary canal, the cellular tissue, and the serous cavities into which they have been introduced. Hence they must have been either decomposed or absorbed.

Drs. Christison and Coindet[2] found that four ounces of a solution of oxalic acid injected into the peritoneal sac of a cat, killed the animal in fourteen minutes. On a post-mortem examination, although none of the fluid had escaped by the wound, they found scarcely a drachm remaining.

2. *Detection of medicines and poisons in remote parts.*—Medicines and poisons have been detected by their sensible qualities (odour, colour, and taste), by their chemical properties, or by their medicinal or poisonous qualities, in parts remote from that to which they were applied.

a. In the blood and chyle.—In the blood and chyle, but especially in the former liquid, numerous substances have been detected by Tiedemann and Gmelin[3], and by other experimenters. The following substances have been detected in the *blood*[4]:—

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[1] See Dr. Marshall Hall's *Gulstonian Lectures* for 1842, p. 64.

[2] *Edin. Med. and Surg. Journ.* xix. 335.

[3] *Versuche über die Wege auf welchen Substanzen aus dem Magen u. Darmkanal ins Blut gelangen.* Heidelberg, 1820.

[4] The authorities or evidence in support of the above statement will be given hereafter under the head of each substance.

Bromine.
Iodine.
Lead.
Copper.
Mercury.
Arsenic.
Silver.
Tin.
Iron.
Antimony.
Zinc.
Bismuth.
Barium.
Cyanide of potassium.
Sulphocyanide of potassium.
Sal ammoniac.
Nitrate of potash.
Iodide of potassium.
Chlorate of potash.
Sulphuret of potassium.
Sulphuretted hydrogen.
Quinine.
Colouring principle of
  indigo,
  rhubarb,
  madder.
Hydrocyanic acid.
Sulphocyanic acid.
Carbazotic acid.
Oxalic acid.
Oil of turpentine.
Alcohol.
Camphor.
Odorous principle of
  musk,
  assafœtida.
Dippel's oil.

Tiedemann and Gmelin administered a variety of colouring, odorous, and saline substances to animals, mixed with their food, and afterwards examined the state of the *chyle*, and of the blood of the (splenic, mesenteric, and portal) veins. Most of them were found in the blood and urine; but none of the colouring or odorous substances could be detected in the chyle, and a few only of the salts were found in it. From these experiments we may conclude, that although saline substances occasionally pass into the chyle, odorous and colouring matters do not: all the three classes of substances, however, are found in the venous blood. These results, observe Tiedemann and Gmelin, are opposed to those obtained by Lister, Musgrave, J. Hunter, Haller, Viridet, and Mattei, but agree with those of Hallé, Dumas, Magendie, and Flandrin.

β. *In the solids* of the body various medicinal substances have been detected; as mercury and the colouring matter of madder in the bones, silver in the brain and skin, lead in the liver, spinal cord, muscles, &c. The following substances have been detected in the *solids*:—

Bromine.
Sulphur.
Mercury.
Silver.
Lead.
Copper.
Arsenic.
Antimony.
Ferro-cyanide of potassium.
Alcohol.
Colouring principle of
  madder,
  indigo,
  logwood.

γ. *In the excretions.*—Foreign substances which have been introduced into the circulating mass are separated from the blood, and in this way are got rid off by the excreting organs, especially by the kidneys. Hence traces of medicines or poisons which have been swallowed, or otherwise taken into the system, are usually discoverable in the urine or other secretions.

αα. The most extensive and careful series of experiments made on the passage of foreign substances from the intestinal canal into the *urine* are those of Wöhler[1] and Stehberger[2]. The following substances are mentioned by Wöhler as reappearing in the urine:—

1. *Substances which pass off by the urine unchanged.*

Salts.

Carbonate of potash.
Nitrate of potash.
Chlorate of potash.
Sulphocyanide of potassium.
Sulphuret of potassium (but for the most part decomposed).
Ferrocyanide of potassium.
Silicate of potash.
Tartrate of nickel and potash.
Borax.
Chloride of barium.
Iodide of potassium.

Colouring Principles

Of indigo.
" madder.
" rhubarb.
" gamboge.
" logwood.
" red beet.
" mulberry.
" black cherry.
" bilberry.
" cassia fistula.
Of elder rob.
" cactus opuntia.
" chelidonium majus.
" cistus laurifolius.
" prunes.
Reddish yellow colouring matter of nux vomica bark.
Green fat of turtle.

Odorous Principles somewhat altered.

Oil of turpentine.
" juniper.
Of valerian.
" saffron.
" assafœtida.
" garlic.
" castoreum.
" opium.
" asparagus.
" viola tricolor.

Narcotic Principle

Of amanita muscaria.

Fixed Oil

Of almonds.

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[1] Tiedemann and Treviranus, *Zeitschrift für Physiologie*, Bd. i. S. 125, 1824.
[2] *Ibid.* Bd. ii. S. 47.

2. *Substances which pass in a state of combination.*

Sulphur, as sulphuric acid and sulphuretted hydrogen.
Iodine, as hydriodic acid or iodide.
Oxalic
Tartaric
Gallic
Succinic
Benzoic[1]
acids, appear in combination with an alkali.
Astringency of uva ursi.
" " cinchona.

3. *Substances which pass in a decomposed state.*

Tartrate
Citrate
Malate
Acetate
of potash, or soda, are changed into the carbonate of the same alkali.
Sulphuret of potassium, changed, in a great measure, into the sulphate of potash.
Ferridcyanide of potassium, changed into ferrocyanide of potassium.

Subsequently to the publication of Wöhler's paper, a considerable number of other substances have been detected in the urine, though, in several cases, the state in which they pass out of the system has not been clearly determined. The most important of these substances are as follows:—

Bromine.
Arsenic.
Antimony.
Bismuth.
Lead.
Gold.
Silver.

Tin.
Mercury.
Iron.
Sulphuric acid.
Nitric acid.
Hydrochloric acid.
Phosphoric acid.

Tannic acid.
Meconic acid.
Alum.
Bromide of potassium.
Eau de Javelle.
Quinine.
Morphia.

Narcotic principle of
belladonna,
stramonium,
henbane.
Colouring principle of
winter green,
sumach.

In consequence of the general occurrence of poisonous substances in the urine, their detection in this secretion becomes, in cases of poisoning, an important subject of medico-legal research[2].

ββ. In the *breath*, many volatile substances have been detected by their odour.

Alcohol.
Ether.
Camphor.
Sulphuret of carbon.
Wine.
Turpentine.

Dippel's oil.
Odorous principle of
assafœtida,
garlic,
onions,
vanilla,
cloves.

Odorous principle of
cinnamon,
anise,
fennel,
caraway,
horse radish,
pepper.

Phosphoric fumes (from phosphorus).
Sulphuretted hydrogen (from sulphuret of potassium).

γγ. In the *milk*, a considerable number of substances have been recognised either by their sensible or chemical properties, or by their physiological effects (see p. 104).

Iodine.
Lead.
Zinc.
Bismuth.
Iron.

Mercury.
Carbonate of soda.
Iodide of potassium.
Sulphate of soda.

Purgative principle of senna.
Narcotic principle of opium.

Quinine.
Colouring matter of
indigo,
madder.

δδ. In the *cutaneous transpiration*, several medicinal substances have been detected by their odour, colour, or other properties.

Sulphur.
Iodine.
Mercury.

Odorous principle of
musk,
garlic,
onion.

Odorous principle of
assafœtida,
camphor.
Wormwood.

Colouring principle of
indigo,
rhubarb,
saffron.

εε. Both in the *nasal secretion* and in the *tears*, iodine has been detected: in the former case, by its odour; in the latter, by the formation of iodide of mercury on the application of calomel to the eye of a patient to whom iodide of potassium had been administered[3].

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[1] Mr. Ure (*London Medical Gazette*, vol. i. 1840-41, p. 735,) has shown that the urine voided after the ingestion of benzoic acid contains hippuric acid.

[2] Orfila, *Journal de Chimie Méd.* t. viii. 2e sér. 1842; also, *Traité de Toxicologie*, 4me éd. 1843.

[3] Fricke, *Annalen der Pharmacie*, xxiv. 74, 1838.

3. *Prevention of remote effects by the prevention of the circulation of medicines and poisons.*—Segalas tied the veins of a portion of intestine, and applied poison, but no effects were produced. Emmert also observed, that when the abdominal aorta was tied, hydrocyanic acid did not give rise to any effect when applied to the foot; but, when the ligature was removed, symptoms of poisoning came on[1]. Lastly, Dr. Blake[2] found, that if a ligature be put around the vena portæ, and then poison be introduced into the stomach, it failed to act.

It deserves notice, that the Academy of Medicine of Philadelphia found that nux vomica, introduced into the intestines, produced tetanus, although the vena portæ was tied[3].

The cardiac orifice of the stomach should be tied to prevent the escape of the poison into the œsophagus. When this precaution is adopted, a ligature placed on the vena portæ prevents the action of poisons introduced into the stomach, as I myself have witnessed.

4. *Promotion or retardation of remote effects by the promotion or retardation of the absorption and circulation of medicines and poisons.*—The remote effects of medicinal and poisonous agents are promoted or retarded by circumstances which promote or retard absorption. Three of these circumstances deserve separate notice.

α. *Nature of the tissue.*—Nux vomica acts with great energy when applied to the pulmonary surface, with less when introduced into the stomach, and with the least of all when applied to the skin. The same order of gradation is observed with respect to opium. Now, the faculty of absorption, or of imbibition, as Magendie calls it, does not take place with equal intensity in all tissues. Certain physical conditions (viz. a fine and delicate structure and great vascularity) enable the pulmonary surface to absorb or imbibe with extreme rapidity: in this respect, indeed, it is not equalled by any tissue of the body. But the membrane lining the alimentary canal absorbs with less facility than the pulmonary membrane, in consequence of its being less vascular, and covered by an epidermoid layer and by mucus, which check absorption: while the cutaneous surface, being invested by an inorganic membrane (the epidermis) does not possess the same physical faculties for absorption met with in either of the foregoing tissues; and hence the comparative inertness of medicines when applied to it. In fact, it is only by the long-continued application of these agents to the skin, or by the removal of the epidermis, that we are enabled to affect the general system.

β. *The physical and chemical properties of medicines.*—The effect of many medicines is in proportion to their solubility. Thus arsenious acid and morphia are both more energetic in solution than in the solid state. Now liquids (particularly those miscible with the blood) are much more readily absorbed than solids. In the treatment of cases of poisoning, we endeavour to take advantage of this fact, and, by rendering substances insoluble, diminish their activity, or render them quite inert.

γ. *Condition of system.*—Magendie asserts, as the result of experiments, that plethora uniformly retards, and depletion as constantly promotes, absorption; and, therefore, that when we wish to promote this function, we may do so by blood-letting. Now one means of promoting the action of mercurials on the mouth is to abstract blood; and, in theory, the best means of preventing the operation of poisons is to throw a quantity of warm water into the veins; a practice which Magendie tried on animals, and found successful. Caution, therefore, is recommended in the employment of blood-letting in cases of narcotic poisoning while the poison is in the stomach.

5. *Similarity between the remote and the topical effects.*—The action of a medicine is limited to the part with which medicinal molecules are in contact; but it is not confined to the part to which the medicinal agent was first applied; since by absorption and passage into the blood the molecules may be conveyed to distant parts, on which they may also act. If they are absorbed unaltered,

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[1] Müller's *Elements of Physiology*, by Baly, vol. i. p. 242.

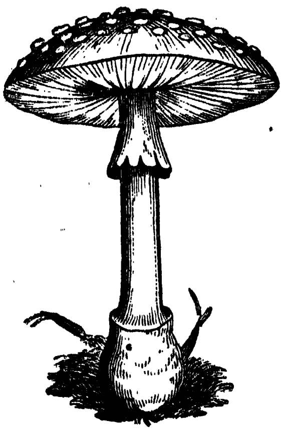
[2] *Edinb. Med. and Surg. Journ.* vol. liii. p. 45.

[3] Müller, *op. supra cit.* vol. i. p. 240.

and suffer no change during their passage through the system, their action on remote parts is identical with that on the parts to which they were first applied. But if, in consequence of their contact with the living body, they have undergone chemical change, their action is modified accordingly. Cantharides produce irritation and inflammation of the skin and mucous membranes when applied to these parts; and not unfrequently, in consequence either of their external employment in the form of blister, or of their internal administration, they also produce irritation and inflammation of the bladder and kidneys. The latter effects may be ascribed to the absorption of the cantharidin (the active principle of the insects) into the blood, its passage out of the system by the kidneys, and its action first on the bladder (with the mucous membrane of which it remains for some time in contact) and afterwards on the kidneys. Oil of turpentine, which also irritates and inflames the skin and mucous membranes when placed in contact with them, acts in a similar way on the bladder and kidneys.

6. *Medicinal or poisonous properties of the fluids and solids after the use of medicines or poisons.*—The *milk* is frequently found to have acquired medicinal qualities in consequence of the employment of medicinal substances by the mother or wet-nurse: it is rendered purgative by senna, emetic by tartarized antimony, narcotic by opium, tonic by quinine and other bitters, antacid by alkalies, and anti-syphilitic by mercury[1]. The *urine*, in the same way, sometimes acquires medicinal or poisonous properties. Runge[2] found that the urine of rabbits which had been fed with belladonna, stramonium, and henbane, caused dilatation of the pupil when applied to the eye of another animal. But the most remarkable illustration is that of the *Amanita muscaria* (fig. 7), a fungus employed by many Siberian tribes (the Samoyedes, the Ostiaks, the Toongooses, the Yakutes, the Yookahires, the Koriakes, the Tshooktshes, but especially the Kamtschatdales,) as a substitute for alcoholic liquors to produce excitement and inebriation. It imparts an intoxicating quality to the urine, which continues for a considerable time after taking it. A man, for example, may have intoxicated himself to-day by eating some of the fungus; by the next morning he will have slept himself sober; but by drinking a tea-cupful of his urine, he will become as powerfully intoxicated as on the preceding day. "Thus," says Dr. Greville[3], on the authority of Dr. Langsdorf, "with a

FIG. 7.



Amanita muscaria.

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[1] Dr. Locock, in *The Cyclop. of Pract. Medicine*, art. *Lactation*, states that a patient of Mr. Keate took mercury by giving the nitrate of this metal to an ass, and drinking the milk.

[2] *Mémoire inédit lu à l'Institut.* (Orfila, *Traité de Toxicologie*, 4me éd. t. ii. p. 266). Orfila has repeated Runge's experiments, and denies their accuracy. Dr. Letheby (*Lond. Med. Gaz.* Jan. 22, 1847), however, states that he detected the presence of the active principles of "opium, belladonna, hemlock, aconite," &c. in urine by the effect of this excretion on other animals.

[3] *Memoirs of the Wernerian Natural History Society*, vol. iv. part ii. p. 343, 1823. See also on this subject, Phoebus, *Deutschlands kryptogamische Giftgewächse*, p. 27, 1838; *The History of Kamtschatka and the Kurilski Islands* [by Steller and Krasheninicoff], translated [from the Russian] by Dr. J. Grieve, p. 208, Gloucester, 1764.

very few *Amanitæ*, a party of drunkards may keep up their debauch for a week;" and "by means of a second person taking the urine of the first, a third of the second, and so on, the intoxication may be propagated through five individuals."

The *blood* of an animal under the influence of poison has been found to possess poisonous properties. Vernière[1] ascertained that if the extract of nux vomica "be thrust into the paw of an animal after a ligature has been tightened round the leg, so as to stop the venous, but not the arterial, circulation of the limb, blood drawn from an orifice in a vein between the wound and ligature, and transfused into the vein of another animal, will excite in the latter the usual effects of the poison, so as even to cause death; while, on the contrary, the animal from which the blood has been taken will not be affected at all, if a sufficient quantity is withdrawn before the removal of the ligature."

Lastly, the *flesh* of poisoned animals has, in some cases, been found to possess deleterious qualities[2].

7. *Division of the spinal cord, or of all parts except the blood-vessels, does not prevent the remote effects.*—Some poisons, as hydrocyanic acid, are equally active when applied to the legs of an animal whose spinal marrow has been divided. In this case, the effect of the poison could not be the result of its action on the nerves of sensation and voluntary motion.

It has been objected that the division of the lumbar spine does not prevent the action of poisons by the nervous system, because it does not destroy the action of the excito-motory or sympathetic system, the nervous branches of which are distributed to the lining membrane of the blood-vessels. I am aware that it is an experiment liable to objection; but, on the whole, it is certainly favourable to the opinion of the operation of poisons by absorption; more particularly when we bear in mind that the motion of the blood is necessary to the action of the poison; for if the circulation of a part be obstructed, the poison will no longer act.

Magendie and Delille[3] divided all the parts of one of the posterior extremities of a dog, except the artery and vein, the former being left entire, for the purpose of preserving the life of the limb. A portion of the *upas tieuté* was then applied to a wound in the foot: in the short space of four minutes the effects of the poison were evident; and in ten minutes death took place. It was inferred, therefore, that the poisoning took place by venous absorption.

Several objections have been raised to this inference: first, the exhibition of opium, to diminish the pain of the operation, has been said to vitiate the whole of the experiment; secondly, the coats of the arteries and veins contain lymphatics, by which absorption might be carried on; and thirdly, as the poison was introduced into a wound, the poison might have combined with the blood, and have rendered it deleterious, without the process of absorption taking place. The first two of these objections have been obviated. In a second experiment, Magendie severed the artery and the vein, and reconnected them by quills, so as to preclude the possibility of absorption taking place by the lymphatics: the effects were the same. Some years since I assisted in performing an analogous experiment, using *strychnia* instead of the *upas tieuté*, and without administering opium: death, preceded by the usual symptoms of poisoning, took place in twelve minutes.

8. *Production of remote effects by the injection of medicines or poisons into the blood.*—Medicinal or poisonous agents, injected into the blood-vessels, exert the same kind of specific influence over the functions of certain organs

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[1] *Journal des Progrès des Sciences Méd.* 1827, iii. 121, quoted by Dr. Christison, *Treatise on Poisons*, 4th ed. p. 14.

[2] See on this subject, Christison, *op. cit.* 4th ed. p. 80.

[3] Magendie's *Elementary Compend. of Physiology*, translated by Dr. Milligan, p. 284, Edin. 1823.

as when they are administered in the usual way; but that influence is more potent. Thus, tartar emetic causes vomiting, castor oil purging, opium stupor, and strychnia convulsions, when thrown into the veins.

RAPIDITY OF ABSORPTION.—Dr. Blake[1] states that the rapidity of the action of a poison is in proportion to the rapidity of the circulation. Thus a substance injected into the jugular vein of a horse, arrives at the capillary termination of the coronary arteries in ten seconds; of a dog, in twelve seconds; of a fowl, in six seconds; of a rabbit, in four seconds; and he adds, that the time required for the first symptoms of the poison to present themselves, bears a close relation to the rapidity of the circulation. Professor Hering, of Stuttgardt[2], found that the time which a solution of ferrocyanide of potassium, injected into the jugular vein, requires to reach that of the opposite side, was, in various experiments, from twenty to thirty seconds. And Dr. Blake[3] states that, in dogs, a substance which does not act on the capillary tissue passes from any part of the vascular system back to the same part again in from twelve to twenty seconds. But, rapid as is the circulation of poisonous molecules, it has been supposed not to be sufficiently so to explain the operation of certain poisons which have been said to act instantaneously; and hence an argument has been raised in favour of the nerves being the medium by which the deadly impression is conveyed. To this Dr. Blake[4] replies, that an interval, always more than nine seconds, elapses between the introduction of a poison into the capillaries or veins, and the first symptom of its action;—a period sufficiently long for a poison to be brought into general contact with the tissues it affects.

ORGANS OF ABSORPTION OF MEDICINES.—The particles of medicinal and poisonous substances are absorbed by the veins principally, but also by the lymphatics and lacteals.

The absorption of these substances by the veins is proved by the following circumstances:—

1. The detection of medicines and poisons in the venous blood (see p. 101).
2. The occurrence of symptoms of poisoning when the poisoned part communicates with the general system merely by the medium of the blood (see p. 105).
3. Magendie states that ligature of the lacteals does not prevent the occurrence of poisoning by agents introduced into the intestines.
4. Ligature of the blood-vessels prevents the occurrence of symptoms of poisoning (see p. 102).

But absorption is also effected by the lymphatics and lacteals (see p. 101), though it appears to be slow, and confined to certain agents.

MECHANISM OF ABSORPTION OF MEDICINES.—The absorption of medicines consists of two acts; first, their passage through the interstices of the organised tissue with which they are placed in contact, and secondly, their diffusion and circulation.

a. The passage of medicinal substances through organised tissues is effected by imbibition and endosmose, and is exclusively a physical action.

Magendie exposed and isolated the jugular vein of a dog, placed it on a card, and dropped some aqueous solution of the extract of nux vomica on its surface, taking care that the poison touched nothing but the vein and the card. In four minutes the effects of the substance became manifest, and the dog died[1]. It must be admitted, however, that the result of this experiment does not absolutely prove, though it strongly supports, the opinion of the imbibing power of the living vessels; for it might be objected, that the nerves of the venous coats propagated the impression of the poison, and that death took place without absorption; or, that the small veins of the venous coat had taken up the poison. The proof, therefore, should consist in the detection of the poison within the vessel. Now this has been obtained by Magendie: a solution of nux vomica was placed on the carotid artery of a rabbit; but as the tissue of arteries is firmer and less spongy, and their parietes thicker, than those of veins, a longer time elapsed before the poison traversed the vessel. In fifteen minutes, however, it had passed, and on dividing the vessel the blood adherent to its inner wall was found to possess the bitter taste of the poison.

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[1] *Lond. Med. Gaz.* for June 18, 1841.

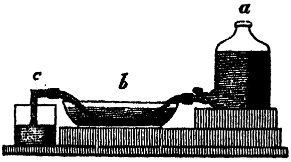
[2] Tiedemann and Treviranus, *Zeitschrift für Physiologie*, iii. p. 122.

[3] *Edin. Med. and Surg. Journ.* vol. liii. p. 42.

[4] *Ibid.* p. 49.

β. The diffusion and circulation of medicinal substances, after they have passed through the coats of the vessels, are effected by the circulating blood, and are physical phenomena.

FIG. 8.



Apparatus to illustrate Physical Absorption.

The following experiment is a physical illustration of both imbibition and circulation of medicinal substances:—If a current of water, coloured by litmus, be allowed to pass from a bottle (fig. 8, *a*), through a vein immersed in diluted sulphuric acid, contained in a glass dish (*b*), into a reservoir (*c*), the litmus liquor is soon observed to become reddened by its passage through the vein, in consequence of the acid permeating the venous coats. If the relative position of the fluids be altered,—that is, the litmus put in the dish (*b*), and the acid passed from the bottle (*a*) through the vein,—the litmus will still become reddened; shewing that the acid has passed, in this case, from within outwards.

Gases and vapours, as well as liquids, also readily permeate dead animal membrane. But the same membrane is unequally permeated by different gases.

Although the acts by which the absorption of medicines is effected may be thus regarded as physical, yet vital actions are so far necessary to the process, that they supply the conditions under which the physical phenomena are manifested.

Thus, though dead tissues imbibe, and though endosmose takes place through a dead as it does also through a living membrane, yet the vital actions of the heart and lungs are necessary to keep up the circulation of the blood, by which the medicinal molecules are conveyed to distant parts, and the further imbibition and endosmose of the medicine promoted.

ACTION OF MEDICINES SUBSEQUENT TO ABSORPTION.—Medicinal substances, after their introduction into the blood, circulate with this liquid, traverse the capillaries of the various organs of the body, and are ultimately thrown out of the system by the excreting organs. We have, therefore, to consider their action, first, on the blood; secondly, on the tissues of organs; thirdly, on the excreting organs.

1. *Action of medicines on the blood.*—A considerable number of medicinal substances, after their introduction into the circulation, produce changes in the condition of the blood. But neither the precise nature of these changes, nor the particular symptoms which they give rise to, have as yet been accurately determined.

As the living blood consists of two parts, viz. corpuscles, and a clear liquid called plasma or liquor sanguinis, it will be convenient to notice separately the action of medicines on each of these parts.

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[1] Magendie, *Lectures*, in the *Lancet*, Oct. 4, 1834.

a. Action of medicines on the blood-corpuscles.—If we assume the blood-corpuscles to be endowed with vitality, we may regard the effects of medicines on them as three-fold; viz. physical, chemical, and vital.

The well-established endosmotic effect of medicines on the blood-corpuscles, and to which I have already had occasion to refer (see p. 92), is an instance of a *physical* effect. Under the influence of certain agents, these bodies become distended, and even burst; while, under the influence of others, they are more or less completely emptied of their liquid contents, and thereby become collapsed, shrivelled, and corrugated.

That *chemical* effects are also produced on the blood-corpuscles can scarcely, I think, be doubted, though it is difficult to adduce unequivocal evidence of this. The alteration produced in the colour of the blood by the action of poisons (*e. g.* sulphuretted hydrogen and hydrocyanic acid), and the effects of chalybeates in restoring a healthy vermilion tint to anæmic subjects, must be consequences of chemical changes effected in the contents of the red corpuscles.

The *vital* effects are more obscure than either of the two preceding effects; and Schultz[1], who is the great advocate of their existence, obviously confounds many physical and chemical effects with them. He believes that the capsule of the corpuscle is an organised structure possessing vitality; and he admits two kinds of vital effects produced on it: the one, which he calls stimulating or anabiotic; the other, paralysing or biolytic (see p. 95). The former are especially produced by the ethereal and aromatic substances; the latter, by water, diluted acids, the haloid substances (particularly iodine), prussic acid, belladonna, and henbane. Medicines, says Schultz, cause biolytic effects by lessening the contractility of the blood-corpuscles; and these are in consequence rendered unfit for respiration, and are incapacitated for firmly retaining the colouring matter, which, in consequence, is more or less dissolved by the plasma. Water, an important biolytic agent, operates more negatively than positively, since, by diluting the plasma, it lessens the stimulating influence of the dissolved salts on the blood-corpuscles. Salts, on the other hand, strongly excite the corpuscles to contract, and cause them to retain firmly the colouring matter, which, therefore, is not given up to the plasma.

But Dr. Rees, to whose writings I have before had occasion to refer (see p. 92), has clearly proved that the effect of water and saline solutions on the blood is physical, being produced by endosmose.

According to Mialhe[2], medicines and poisons have four kinds of action on the blood:—

1. Some moderate its course by more or less coagulating its serum, &c.: as nitric acid, creosote, alcohol, the poisonous principle of fungi, metallic salts, &c. The same effect is produced by the precipitation in the blood of insoluble bodies: as the salts of strontian, of lime, of baryta, &c.
2. Some liquefy the blood, and accelerate its course: as the acetates of ammonia, nitrate of potash, the iodides, bromides, &c.
3. Some modify the chemical reactions which take place in this liquid, and which are most frequently effected by seizing its oxygen, a phenomenon which prevents hæmatosis, and produces chlorosis, anæmia, &c.: as is the case with sulphuretted hydrogen, and especially with hydrocyanic acid, which produces instantaneous death in a manner hitherto inexplicable, and which may be ascribed to the catalytic force.

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[1] *Natürliches System der allgemeinen Pharmakologie*, pp. 155 and 161.

[2] *Traité de l'Art de Formuler*, quoted by Merat, in the *Supplement au Dictionnaire univ. de Mat. Med.* p. 465, 1846.

4. Some produce abnormal chemical reactions in it: as the poison of rabid animals, the venom of poisonous serpents, &c. which seem to act in the manner of ferments, whose effects appear to be destroyed by the caustic alkalies, powerful acids, fire, &c.

β. Action of medicines on the plasma.—There are, at least, two kinds of effects produced by medicinal and poisonous agents on the blood, which are referable to the action of these substances on the plasma. These are, an alteration in the consistence of the blood, and a change in its coagulability.

In animals poisoned by hydrocyanic acid, as well as by other agents, alterations in the consistence of the blood have been frequently noticed; and it is probable that many medicinal agents produce some effect of the same kind; but our information on this point is very vague and unsatisfactory, owing principally to the difficulty or impossibility of correctly estimating slight changes of consistence.

The coagulation of the blood may be retarded or promoted, and the quantity of fibrine obtained therefrom lessened or augmented, by various medicinal and poisonous agents. Thus the neutral salts and narcotics for the most part retard or prevent the coagulation. It is well known that the addition of nitre or sulphate of soda to fresh-drawn blood impedes the coagulation; and the same effect appears to be produced by administering these salts to living animals. In a case of acute pneumonia in a robust countryman, Schultz abstracted two ounces of blood, a quantity which could have but little, if any, influence on the residual blood in the system. The blood thus abstracted yielded 5 per cent. of fibrine. At the end of twenty-four hours, during which time the patient had taken three drachms of nitre and an ounce of sulphate of soda, two ounces of blood were again drawn; and this portion yielded only 3·4 per cent. of fibrine. The use of the nitre and alkaline sulphate was persevered in, and, at the end of twenty-four hours more, the patient was again bled to the same extent: but this portion of blood yielded only 1·9 per cent. of fibrine. Thus, then, it appears that, under the continued use of these salts, the quantity of spontaneously coagulating matter (fibrine) in the blood progressively lessened. This effect has been termed *anti-plastic* or *plastilytic*. Stimulants, such as the volatile oils and alcohol, have an opposite or *anaplasmatic* effect on the blood; that is, they increase the quantity of spontaneously coagulating matter.

2. *Action of medicines on the tissues of organs.*—The specific operation of medicines, after their absorption, on particular organs is well known. Thus opium acts on the brain, strychnia on the spinal cord, and so on. Poiseuille has ingeniously attempted to explain some of these effects endosmotically, as I have before stated (see *ante*, p. 93); while Percy, on the other hand, has endeavoured to account for them on chemical principles (see *ante*, pp. 87—88). But neither physics nor chemistry appear to be capable of furnishing a satisfactory explanation of the specific effects of medicines, which, therefore, must be referred, at least for the present, to peculiarities in the vital endowments of particular parts.

Action of medicinal substances on the capillary circulation.—According to the experiments of Poiseuille[1], it would appear that certain medicines, when introduced into the blood, modify the circulation in the capillaries of living animals: Those which *facilitate* the capillary circulation are, acetate of ammonia, nitrate of potash, sal ammoniac, chloride of potassium, nitrate of ammonia, iodide and bromide of potassium, and most mineral waters (more than forty were tried). The following substances *retard* the capillary circulation:—Alcohol, chlorides of sodium and magnesium, sulphate of ammonia, &c.; sulphuric, tartaric, oxalic, acetic, &c. acids. Water and ammonia counteract the retardation produced by alcohol.

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[1] *Comptes rendus*, 1843 and 1844.

The opposite effects here stated to be produced by the chlorides of potassium and sodium (salts which closely agree in most of their properties), as well as by different salts of ammonia, throw some doubt over the accuracy of these observations, which require to be confirmed by other experimenters.

3. *Action of medicines on the excreting organs.*—Medicinal and poisonous substances, after they have been taken up and conveyed into the blood, are got rid of by the different excreting organs which expel them from the system.

But the same substances are not thrown out with equal facility by all the excreting surfaces; some showing a preference for one, others for another organ. Thus camphor and alcohol pass out of the system chiefly by the lungs; saline and colouring substances by the kidneys.

The substances which are thus usually thrown out of the system by a certain secreting organ, in general act as stimulants to that organ, and augment its secretion. This is especially the case with the salts which pass out of the system by the kidneys, and which have been long in use as diuretics. We may, therefore, assume that substances which specifically stimulate the kidneys are excreted by these organs; and the same probably holds good with respect to other excreting organs.

The influence which different medicinal substances exercise over the excreting organs, by which they are expelled from the system, is apparently of the same kind as that which the same bodies exercise topically on the parts of the body to which they are first applied (see p. 103).

OBJECTIONS.—The absorption of medicines and poisons has been so fully and satisfactorily proved by numerous experimenters, that the fact is now universally admitted. But it has been denied that this absorption is essential or necessary to the action of these agents on the body. "We must strongly protest," say Messrs. Morgan and Addison, "against the assumption that, because a poison has been found to enter and pass through a vein, it is thence to be inferred that such a process is, under all circumstances, absolutely necessary to its operation." The principal objections which have been raised to the theory of the operation of medicines by absorption are the following:—

1. *The analogy between the effects of injuries and poisons.*—Mr. Travers[1] has forcibly pointed out the analogy observed between the effects of severe injuries and of poisons which operate rapidly on the system; for example, of strychnia and punctured wounds, both of which cause tetanus; and he concludes that their *modus operandi* must, therefore, be identical; and as there is nothing to be absorbed in the one case, so absorption cannot be essential in the other.

But, as Müller[2] has observed, "the fact of two substances producing similar symptoms in one organ does not prove that these substances produce exactly the same effects, but merely that they act on the same organ, while the essential actions of the two may be very different."

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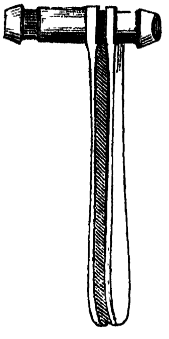
[1] *Further Inquiry concerning Constitutional Irritation.*

[2] *Essay on the Operation of Poisonous Agents*, p. 56, Lond. 1829.

2. *The innocuousness of the blood of a poisoned animal.*—Messrs. Morgan and Addison assert that the blood circulating in the carotid artery of a dog, poisoned by strychnia, is not poisonous to a second dog; and they, therefore, infer that this poison does not act on the brain by absorption, but by an impression upon the extremities of the nerves.

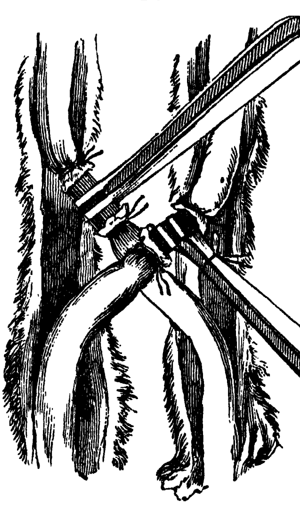
By the aid of a double brass tube (fig. 9), consisting of two short brass cylindrical tubes, to each of which a long handle is attached (fig. 11), they established a complete circulation

FIG. 9.



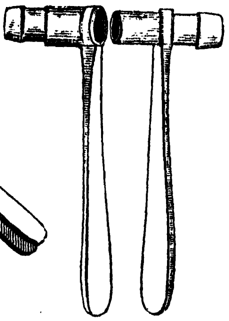
Double Brass Tube.

FIG. 10.



Double Circulation between the Carotids of a poisoned and a sound Dog.

FIG. 11.



Single cylindrical Brass Tubes.

between the carotids of a poisoned and of a sound dog, by connecting the lower and upper ends of the divided arteries in both animals, so that each supplied the brain of the other with the portion of blood which had previously passed through the carotid artery to his own, and, consequently, the poisoned dog in this case received from the unpoisoned animal a supply of arterial blood equal to that with which he was parting (fig. 11). One of the dogs was then inoculated with a concentrated preparation of strychnia, which had been found upon other occasions to produce death in these animals in about three minutes and a half. In three minutes and a half the inoculated animal exhibited the usual tetanic symptoms which result from the action of this poison, and died in little less than four minutes afterwards, viz. about seven minutes from the time at which the poison was inserted, during the whole of which period a free and mutual interchange of blood between the two was clearly indicated by the strong pulsation of the denuded vessels throughout their whole course. The arteries were next secured by ligature, and the living was separated from the dead animal; but neither during the operation, nor subsequently, did the survivor shew the slightest symptom of the action of the poison upon the system.

To the conclusions which have been drawn from this experiment it may be replied, first, that other experiments (see p. 105) have shewn that the blood of a poisoned animal does possess poisonous properties; and secondly, that the experiment of Messrs. Morgan and Addison is open to several objections.

The objections to this experiment are threefold:-

1. A remarkable error pervades the whole train of reasoning adopted by Messrs. Morgan and Addison, and vitiates some of their conclusions. They assume that Magendie considers actual contact with the brain as essential to the operation of the upas poison[1]. This

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[1] See pp. 42, 43, 47, 49, &c. of the *Essay*.

assumption, however, is not correct. "In 1809," says Magendie[1], "I laid before the first class of the French Institute, a series of experiments which had conducted me to an unexpected result; namely, that an entire family of plants (the bitter Strychnos) have the singular property of powerfully exciting the spinal marrow, without involving, except indirectly, the functions of the brain." Now it is evident that, in the experiment performed by Messrs. Morgan and Addison, the blood sent from the carotid artery of the poisoned animal to the brain of the sound one, could only reach the spinal marrow by the usual route of the circulation; that is, it must be returned by the jugular veins to the heart, from thence to the lungs, back again to the heart; from thence into the aorta, and then distributed through the system. Now it is not too much to suppose that, during this transit, some portion of the poison might be decomposed, or thrown out of the system, before it could arrive at the spinal marrow: and even if this were not the case, this organ could only receive a small quantity of the poison contained in the system; namely, that sent by the vertebral to the spinal arteries. Hence we ought to expect that a poison thrown into the arteries will operate less powerfully than when thrown into the veins, unless it be into the arteries supplying the parts on which the poison acts. Moreover, as an anonymous reviewer [Sir David Barry?] has observed[2], it is to be recollected, that as the carotid artery, in its healthy state, is little more than one-fourth of the calibre of the vessels carrying blood directly to the brain, the dog not inoculated consequently was subject to the influence of one-fourth only of the quantity of the poison which was conveyed to the *brain alone* of the inoculated animal.

2. It is probable, I think, that the circulation of the blood through the tube was not so free as through the undivided artery.

3. Dr. Blake[3] asserts, that as "soon as the poison begins to exert its influence on either animal, the pressure in its arterial system will be diminished; and thus, far from the blood containing the poison being sent to the brain of the sound animal, the only effect of the arrangement will be to cause a reflux of pure blood from the arteries of the sound dog into those of the poisoned one."

3. *Rapid action of a poison notwithstanding that its direct entrance into the heart is prevented.*—The following experiments were made by Messrs. Morgan and Addison:—

The jugular vein of a full-grown dog was secured by two temporary ligatures; one of which was tied round the upper, and the other round the lower part of the exposed vein. The vessel was then divided between these two ligatures, and the truncated extremities reconnected by means of a short brass cylinder or tube (fig. 13), within which was placed a portion of woorara, of the size of a grain of canary-seed (fig. 12). Both the temporary ligatures were then removed (fig. 14), the accustomed circulation through the vessels was re-established, and in forty-five seconds the animal dropped on the ground, completely deprived of all power over the muscles of voluntary motion: in two minutes, convulsions and respiration had entirely ceased. This result was to be expected, whatever theory be adopted.

FIG. 12. FIG. 13. FIG. 14.

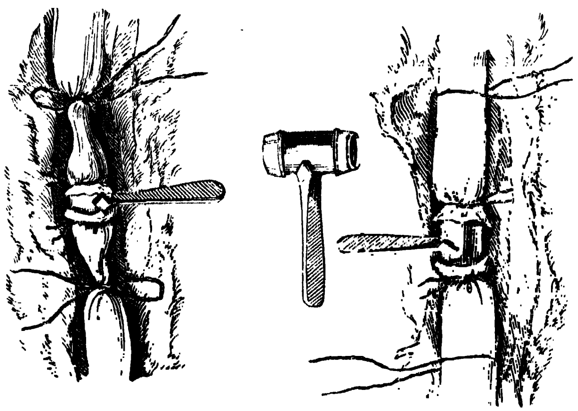

Fig. 12. The divided vein reconnected by a brass tube containing poison. The ligatures not yet removed.
Fig. 13. Brass connecting-tube containing the poison.
Fig. 14. Ligatures loosened.

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[1] *Formulaire*, 8me éd. p. 1.

[2] *Lond. Med. and Phys. Journ.* vol. lxiii.

[3] *Edinb. Med. and Surg. Journ.* vol. liii. p. 48.

In another experiment two temporary ligatures were applied to the jugular vein, as in the former case. A cylinder of quill, containing a little woorara, was introduced into the vein between the two ligatures; another ligature was then applied (fig. 15), and the upper temporary ligature removed (fig. 16). In the space of 108 seconds after the removal of the ligature, the animal dropped in convulsions, as in the former case, and expired in 3½ minutes. Now, in this experiment, the direct entrance of the poisoned blood into the heart, &c. was prevented by the lower ligature; hence, if the poison operated by contact with the brain, a greater length of time was necessary for its effects to be produced; inasmuch as the circulation was no longer going on through the trunk of the jugular itself, and, therefore, if the poison acted by actual contact, it must have got into the system by the vessels of the vein.

FIG. 15.

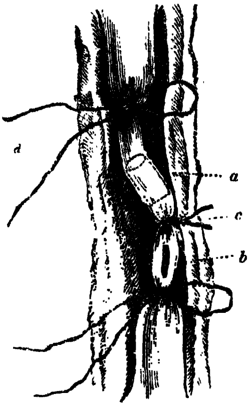

FIG. 16.

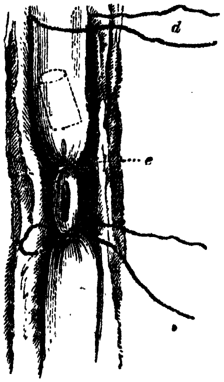

Fig. 15. *a*, Cylinder of quill containing poison introduced into the vein by the aperture, *b*; the ligature, *c*, being afterwards applied. The ligature, *d*, not yet removed.
Fig. 16. Ligature, *d*, unloosened; *e*, remaining.

This experiment, however, cannot be regarded as conclusive. For although the " result is certainly different from what might have been anticipated, on the supposition of the circulation of the poison in the blood being essential to its action, yet we cannot regard it as a conclusion against that supposition, unless it were shown that the poison, when the ligature above it is removed, and when it mingles itself with the stream of blood in the vein, does not taint this blood as far back as the next anastomosing branches, and so make its way forward to the heart. That this is not the effect of removing the farther ligature is not shown by these authors; and their other experiments in favour of their peculiar doctrine of the mode of action of poisons, we have no difficulty in pronouncing to be inconclusive[1]." Moreover, the poison may act by diffusion[2].

4. *Operation of Medicines by Nervous Agency.*

A considerable number of remedial agents operate physically on the body, and affect remote parts through the agency of the nervous system. The most important of these are—electricity, heat, cold, light, mechanical irritants, and corrosives.

Several of the irritant gases produce spasmodic closure of the larynx when an attempt is made to inhale them in the pure and undiluted state. Chlorine, hydrochloric acid gas, ammonia, and carbonic acid, excite this effect. As these substances possess very different chemical properties, while they produce an effect on the glottis which is also produced by mechanical irritation, it is probable that their action is physical. The fit of asthma which is sometimes brought on by inhaling the dust of ipecacuanha is, perhaps, excited in the same way. The great depression of the heart's action which the corrosives occasion when they are swallowed is similar to that caused by wounds or rupture of the stomach, intestine, or gall-bladder, or to the mechanical violence done to a limb in the case of accidents. They act on the principle of shock[1]. "All those substances," says Liebig[2], "which produce the direct destruction of the organs with which they come into contact may be compared to a piece of iron, which can cause death by inflicting an injury on particular organs, either when heated to redness, or when in the form of a sharp knife. Such substances are not poisons in the limited sense of the word, for their injurious action depends merely upon their condition."

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[1] See a criticism in *The British and Foreign Medical Review*, vol. v. for Jan. 1837.
[2] For some remarks on the diffusion of substances introduced into the blood, see Matteucci's *Lectures on the Physical Phenomena of Life*, pp. 352-3. Lond. 1847.

The agents whose operation is of the kind here referred to affect remote parts by the agency of the true spinal and ganglionic systems. The mode of action of those which act through the true spinal system is excited and reflex; that is, an impression is made on, and carried by, the incident excitor nerves to the nervous centre, which, by its peculiar power, affects a remote part through the medium of its reflex motor nerves. The mode of operation of those agents which act through the ganglionic system is excited, and, perhaps, may also be reflex.

Medicines and poisons, properly so called, were formerly supposed to act, not by absorption, but through the agency of the nervous system. In the present state of our knowledge, however, this notion is quite untenable. For while the evidence adduced in favour of the opinion that medicines operate in consequence of absorption almost amounts to absolute demonstration, the arguments in favour of the sympathetic action of these agents are few, feeble, and of doubtful validity. The experiments of Dr. Blake, some of which I have already (p. 106) had occasion to notice, appear to me to have given the *coup-de-grâce* to the latter hypothesis.

Of the various circumstances which have been adduced in favour of the sympathetic action of medicines, two only deserve to be noticed. They are—

1. The velocity of operation of some poisons.
2. The limited nervous transmission of local impressions produced by certain medicinal agents.

1. The velocity of operation of some poisons (*e. g.* hydrocyanic acid, conia, &c.) has been thought to be incompatible with any other mode of operation but that by nervous impression.

Dr. Blake[3] has met this argument by declaring that poisons are not instantaneous in their action, but that sufficient time always elapses between the application of a poison and the first symptom of its action, to admit of its contact with the tissue which it affects. Thus he found, that after half a drachm of concentrated hydrocyanic acid had been poured on the tongue, eleven seconds elapsed before any morbid symptom appeared, and death did not occur until thirty-three seconds after the exhibition of the poison; and on repeating Dr. Christison's experiment, he found that fifteen seconds elapsed after ten drops of conia (saturated with hydrochloric acid) had been injected into the femoral vein of a dog, before symptoms of the action of the poison appeared; and death did not occur until thirty seconds after the injection. Now the time required for a substance to be absorbed by the capillaries, and diffused through the body, may not exceed, according to Dr. Blake, nine seconds. So that the interval which elapsed in the preceding experiments, between the application and the effect, is quite sufficient to admit of the absorption and diffusion of the poison (see *ante*, p. 106).

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[1] Dr. Marshall Hall's *Gulstonian Lectures* for 1842, p. 67.

[2] Liebig's *Organic Chemistry in its Application to Agriculture and Physiology*, edited by Lyon Playfair, Ph.D. 2d edit. p. 353, Lond. 1842.

[3] *Edinb. Med. and Surg. Journ.* vol. liii. p. 35.

2. "It is maintained," says Dr. Christison[1], "that a limited nervous transmission,—that is, the conveyance of a local impression, purely functional in its nature, to parts at a short distance from the texture acted on directly,—must occur in some instances; as, for example, in the action of belladonna in dilating the pupil when applied to the conjunctiva of the eye, and in the effect of opium in allaying deep-seated pain when applied to the integuments over the affected part."

But this, in reality, is no argument. The dilatation of the pupil produced by the application of belladonna to the conjunctiva, or even to the temples, is a fact which may be explained as well by vascular as by nervous agency.

5. *Circumstances which modify the Effects of Medicines.*

The circumstances which modify the effects of medicines may be arranged under two heads; those relating to the medicine, and those relating to the organism.

1. RELATING TO THE MEDICINE.—Under this head are included—

a. State of Aggregation.—The state of aggregation of a medicine modifies the effect. Thus morphia is more active in solution than in the solid state.

b. Chemical Combination.—The soluble salts of the vegetable alkaloids are more active than the uncombined alkalis; and *vice versâ*, the insoluble salts are less active. Lead and baryta are rendered inert by combination with sulphuric acid.

c. Pharmaceutical Mixture.—The modifications produced by medicinal combinations have been very ably described by Dr. Paris[2]. The objects to be obtained, he observes, by mixing and combining medicinal substances, are the following:—

OBJECT I.—*To promote the action of the basis or principal medicine:*—

α. By combining the several different forms or preparations of the same substance.

β. By combining the basis with substances which are of an analogous nature, *i. e.* which are individually capable of producing the same or kindred effects.

γ. By combining the basis with substances of a different nature, and which do not exert any chemical influence upon it, but are found, by experience, or inferred by analogy, to be capable of rendering the stomach, or system, or any particular organ, more susceptible of its action.

OBJECT II.—*To correct the operation of the basis, by obviating any unpleasant effects it might be likely to occasion, and which would pervert its intended action, and defeat the object of its exhibition.*

α. By chemically neutralizing or mechanically separating the offending ingredient.

β. By adding some substance calculated to guard the stomach or system against its deleterious effects.

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[1] *Treatise on Poisons*, 4th ed. 1845, p. 7.

[2] *Pharmacologia*, 9th edit. p. 373, *et seq.* 1843.

OBJECT III.—*To obtain the joint operation of two or more medicines.*

- α. By uniting those substances which are calculated to produce the same ultimate results, but by modes of operation totally different.
- β. By combining medicines which have different powers, and which are required to obviate different symptoms, or to answer different indications.

OBJECT IV.—*To obtain a new and active remedy not afforded by any single substance.*

- α. By combining medicines which excite different actions in the stomach and system, in consequence of which new or modified results are produced.
- β. By combining substances which have the property of acting chemically upon each other; the results of which are—
  - *a.* The formation of new compounds;
  - *b.* The decomposition of the original ingredients, and the development of their more active elements.
- γ. By combining substances, between which no other chemical change is induced than a diminution, or increase, in the solubility of the principles in which their medicinal virtues reside.
  - *a.* By the intervention of substances that act chemically.
  - *b.* By the addition of ingredients whose operation is entirely mechanical.

OBJECT V.—*To afford an eligible form.*

- α. With reference to its efficacy.
- β. With reference to its taste or appearance.
- γ. With reference to its consistence or equable mixture.
- δ. With reference to its preservation.

d. Organic peculiarities.—Vegetables have their medicinal properties considerably modified by the nature of the soil in which they grow, by climate, by cultivation, by age, and by the season of the year when gathered.

e. Dose.—The modifications produced in the effects of medicines by differences of dose, are well seen in the case of opium, mercurials, and turpentine.

2. RELATING TO THE ORGANISM.—Under this head are included several circumstances, of which the most important are the following:—

a. Age.—The effects of medicines are modified by the age of the individual. Thus children are more susceptible than adults; and, as a general rule, it may be stated that the dose should be augmented in proportion to the number of years that the patient is old. But this rule does not apply to very aged persons, who require smaller doses than adults in the prime of life.

Gaubius, Young[1], and Hufeland[2], have each laid down rules for the adaptation of the doses of medicines to different ages. But no general rule is of much practical value, since there must be numerous exceptions to it, on account of the different susceptibilities to the influence of different medicines being unequal at the same age. Thus infants are peculiarly susceptible of the influence of opium, and to them this medicine must either not be exhibited at all, or at least, with extreme caution. But the case is far otherwise with respect to calomel and some other medicines.

The following posological table for different ages is a translation of the one contained in the Pharmacopœia of Guy's Hospital, and is more extended than any other which I have met with:

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[1] *Introduction to Medical Literature*, p. 453, 2d edit. Lond. 1823.

[2] *Lehrbuch der allgemeinen Heilkunde*, p. 84, 2te Aufl. Jena, 1830.

Age.	Maximum Dose.		
	One Ounce. ℥j.	One Drachm. ʒj.	One Scruple. ℈j.
Months.			
1	ʒss.	gr. iij.	gr. j.
3	—	iv.	—
6	℈ij.	vj.	ij.
9	—	vij.	—
Years.			
1	ʒj.	viij.	iij.
2	ʒjss.	x.	iv.
3	ʒjss.	xij.	
4*	ʒij.	xv.	v.
5	ʒijss.	xviij.	vj.
6	ʒiij.	xx.	vij.
7	ʒiijss.	xxv.	viij.
8*	℥ss.	ʒss.	℈ss.
10	ʒivss.	gr. xxxv.	gr. xij.
12	ʒv.	xl.	xiv.
13	ʒvss.	—	xv.
15	ʒvj.	xlv.	xvj.
18	ʒvjss.	—	xvij.
20	ʒvij.	l.	xviij.
21 to 45*	℥j.	ʒj.	℈j.
50	ʒvij.	gr. l.	gr. xviij.
60 to 70	ʒvj.	xlv.	xvj.
80 to 90	ʒv.	xl.	xiv.
100*	℥ss.	ʒss.	℈ss.

b. Sex.—The sex has an influence on the operation of medicines. Females possess greater susceptibility of the nervous system, more excitability of the vascular system, and less energy or power, than males; and medicines act on them more rapidly, powerfully, and for a shorter period, than on males. In these respects, indeed, they approach children. Hence, therefore, medicines should be administered in smaller doses, and at somewhat shorter intervals, than to men.

The periods of menstruation, pregnancy, and lactation, are attended with peculiarities in relation to the action of medicines. Drastic purgatives should be avoided during these states, especially during the two first. Agents which become absorbed, and thereby communicate injurious qualities to the blood, are to be avoided during pregnancy and lactation.

c. Mode of life: Occupation.—These circumstances affect the susceptibility of the whole organism, or of different parts, to the influence of external agents.

d. Habit.—The habitual use of certain medicinal or poisonous agents, especially narcotics, diminishes the influence which they ordinarily possess over the body. Of the truth of this statement we have almost daily proofs in confirmed drunkards, in chewers and smokers of tobaccco, and in opium-eaters. Instances of the use of enormous doses of opium, with comparatively slight effects, are found in every work on pharmacology. One of the most remarkable which I have met with, is that related by G. V. Zeviani[1]. A woman of the name of Galvani, during a period of thirty-four years, took more than *two cwt.* of solid opium!! When nineteen years old she fell down stairs, and divided her urethra by a knife. Although the wound healed, she was unable to pass her urine in the usual way, but vomited it up daily with excruciating pain, to relieve which she resorted to the use of opium, the doses of which were gradually increased to 200 grains daily.

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[1] *Sopra un Vomito Urinoso*, in the "*Memorie di Matematica e Fisica della Società Italiana.*" Verona, t. vi. p. 93, 1792-4.

The influence of acrid or irritating substances is but little diminished by repetition,—a remark which applies especially to bodies derived from the mineral kingdom.

Several attempts have been made to account for the effect of habit. Some ascribe it to an increased power acquired by the stomach or tissues of decomposing the medicinal agent[1]. Müller[2], on the other hand, attributes a great number of the instances of habituation to the organ becoming saturated with the medicine, while it remains susceptible of other agents. But a strong objection to this hypothesis is, that the effect of habit is observed principally in the case of vegetable narcotics, and is scarcely perceived in the case of inorganic substances which have the most powerful affinities for the constituents of the animal tissues. The same physiologist ascribes part of the phenomena observed in the effects of habit, to the excitability of the organ being deadened by the stimulus being too often repeated.

e. Diseased conditions of the body.—Diseases of various kinds sometimes have a remarkable influence in modifying the effects of medicines—a fact of considerable importance in practice. Two of the best known instances of this are the diminished influence of opium in tetanus, and of mercury in fever.

Begin[3] has endeavoured to explain the diminished influence of opium in tetanus, by assuming, that the stomach acquires an increase of assimilative power. But Mr. Abernethy[4] found thirty drachms of solid opium undissolved in the stomach of a man who died from traumatic tetanus, and to whom opium was given in enormous doses during life. Moreover, Begin's hypothesis would not explain the diminished influence of mercury in fever.

f. Climate.—The well-known influence of climate in modifying the structure and functions of the animal economy, and in promoting or alleviating certain morbid conditions, necessarily induces us to ascribe to it a power of modifying the effects of medicines. But it is difficult to obtain pure and unequivocal examples of it, in consequence of the simultaneous presence and influence of other powerful agents.

g. Mind.—The effects of medicines are very much modified by the influence of the mind. Hufeland[5] knew a lady who, having conceived a violent aversion to clysters, was thrown into convulsions by the injection of a mixture of oil and milk. I have known the most violent effects attributed to bread pills, which the patients had been previously informed exercised a powerful influence over the system. Much of the success obtained by empirical practitioners depends on the confidence which patients have in the medicines administered.

h. Race.—Differences of race have been supposed to give rise, in some cases, to differences in the action of medicines on the body. Thus Charvet[6] ascribes to this circumstance the different effects of opium on the Javanese and Malays (both belonging to the Mongolian race) as compared with those produced on Europeans, Turks, and Persians (the Caucasian race). "The Javanese," says Lord Macartney[1], "under the influence of an extraordinary dose of opium, becoming frantic as well as desperate, not only stab the objects of their hate, but sally forth to attack, in like manner, every person they meet, till self-preservation renders it necessary to destroy them." A similar account is given by Raynal[2] of the effects of opium on the Malays.

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[1] Christison's *Treatise on Poisons*, pp. 31 and 35, 4th edit. 1845.
[2] *Physiology*, by Baly, p. 60.
[3] *Traité de Thérapeutique*, t. i. p. 113, Paris, 1825.
[4] *Lancet*, vol. v. 1824, p. 71.
[5] *Op. cit.* p. 80.
[6] *De l'Action comparée de l'Opium*, p. 59, Paris, 1826.

i. Temperaments.—Temperament also modifies the influence of medicines on the system. The phlegmatic temperament is less susceptible of the influence of remedies than the choleric, the sanguine, and the melancholic. In the sanguine temperament, stimulants are to be employed very cautiously; in the nervous temperament, evacuants are to be used with great care.

k. Idiosyncrasy.—The influence of idiosyncrasy in modifying the effects of medicines and poisons is, in general, to increase their activity. Thus, some individuals are peculiarly susceptible of the action of opium, others of mercury, and some of alcohol. The dust or odorous emanation of ipecacuanha, in certain persons, produces short and difficult respiration, like that of asthma. The late Mr. Haden[3] has related a case in which two drachms and a half of tincture of colchicum produced death: the mother of the patient was also exceedingly susceptible of the action of colchicum, even in very small doses. In some instances, however, the effect of idiosyncrasy is to diminish the activity of the medicines. Thus some persons are exceedingly insusceptible of the action of mercury.

l. Tissue or *Organ.*—The nature of the part to which a medicine is applied has an important influence over the effect produced. The stomach, for example, is much more susceptible of medicinal impressions than the skin. Opium acts more powerfully when applied to the serous than to the mucous tissues. Carbonic acid operates as a positive poison when taken into the lungs, but as a grateful stimulant when applied to the stomach. The modifications effected in the action of medicines by the differences of tissue or organ, depend partly on the relative rapidity of absorption, and partly, perhaps, on the unequal degree of decomposition which these agents undergo in different tissues[4].

5. THERAPEUTICAL EFFECTS OF MEDICINES.

The effects produced on diseases, by the influence of medicines, are denominated *therapeutical.* They are sometimes termed *secondary*, because, in a great majority of instances, they are subordinate to those already described under the name of physiological.

MODE OF PRODUCTION.—Therapeutical effects are produced in two ways:—

1. *Sometimes medicines remove or destroy the exciting causes of disease* when these are still acting, and are material and cognizable. They do this by either a direct or indirect influence.

a. When they act *directly*, they are termed by Hufeland[5] *specifica*

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[1] *Embassy to China*, vol. i. pp. 263-4, Lond. 1792.

[2] *Histoire Philosophique et Politique des Deux Indes*, t. 1er, p. 359, Genève, 1780.

[3] Dunglison's *Translation of Magendie's Formulary*, with Notes by C. T. Haden, Esq. p. 98, 4th edit. Lond. 1825.

[4] See Christison *On Poisons*, 4th edit. pp. 30-31.

[5] *Op. supra cit.* p. 78.

qualitativa. Antidotes which render poisons inert, and agents which destroy intestinal worms or cutaneous parasites, act in this way.

β. Some of them act *indirectly,* as emetics given to dislodge a biliary calculus, or purgatives to remove irritating matters from the alimentary canal.

2. In a large majority of instances, however, the causes of disease have ceased to act; or, if still acting, are either not cognizable, or, if cognizable, are not of a material nature. In all such cases we administer medicines to alter diseased action. The agents which we employ for this purpose operate either directly or indirectly.

a. They act *directly* when their particles come in contact with the diseased part, either by immediate application to it, as in the case of unguents, lotions, gargles, collyria, injections, and other topical agents; or by absorption, and through the medium of the circulation, as when we employ the turpentines in gleet and leucorrhœa.

β. They act *indirectly* when their influence is exerted directly on some other part, and through this indirectly on the seat of the disease. The beneficial effects of purgatives in cutaneous and cerebral diseases, of diuretics in dropsies, of opium in allaying spasm of the intestinal canal or in checking diarrhœa, and of blisters in intestinal diseases generally, are obtained in this way.

In all these cases, we explain the therapeutic effect by assuming that a new kind of action is set up in the part affected, by which the previous morbid action is superseded; and that the new action, or artificial disease, subsides when the use of the medicine is suspended or desisted from.

Fundamental Methods of Cure.—According to the homœopathists, there are only three possible relations between the symptoms of diseases and the specific effects of medicines—namely, *opposition, resemblance,* and *heterogeneity.* It follows, therefore, that there are only three imaginable methods of employing medicines against disease; and these are denominated *antipathic, homœopathic,* and *allopathic.*

1. *Antipathic.*—The *antipathic* (so called from ἀντί, *opposite,* and πάθος, *a disease*), *enantiopathic,* or *palliative* method, consists in employing medicines which produce effects of an opposite nature to the symptoms of the disease, and the axiom adopted is "*contraria contrariis opponenda.*" Though this principle was admitted in several ancient schools, yet it was explained and carried out at different periods in very different ways. Thus Hippocrates, who may be regarded as the founder of this doctrine, observes[1], that "all diseases which proceed from repletion are cured by evacuation; and those which proceed from evacuation are cured by repletion. And so on in the rest; contraries are the remedies of contraries." The Methodists also adopted it, though in a different sense, when they treated the *strictum* by relaxing agents, and the *laxum* by astringents. The Galenists, likewise, were antipathists, since they employed hot remedies to combat cold diseases, and treated moist maladies by dry remedies.

We adopt this practice when we employ purgatives to relieve constipation; depletion to counteract plethora; cold to alleviate the effects of scalds; narcotics to diminish preternatural sensibility or pain; opium to check diarrhœa; and astringents to combat relaxation.

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[1] *Aphorismi,* Section 2nd.

The homœopathists object to antipathic remedies, on the ground that, though the primary effects of these agents may be opposite to the phenomena of a disease, the secondary effects are similar to them. "Constipation excited by opium (primitive effect) is followed by diarrhœa (secondary effect); and evacuations produced by purgatives (primitive effect) are succeeded by costiveness, which lasts several days (secondary effect)[1]." But the beneficial influence of numerous antipathic remedies (*e. g.* opium in diarrhœa) is too well established to admit of doubt.

2. *Homœopathia.*—The *homœopathic* (so called, from ὅμοιος, *like* or *similar,* and πάθος, *a disease,*) method of treating diseases consists in administering a medicine capable of producing effects similar to the one to be removed, and the axiom adopted is "*similia similibus curantur.*"

Hahnemann's first dissertation on homœopathy was published in 1796, in Hufeland's Journal[2]. In 1805 appeared his "*Fragmenta de viribus medicamentorum positivis.*" But the first systematic account of this doctrine appeared in 1810, in a work entitled "*Organon der rationellen Heilkunde.*"

The following, says Hahnemann, are examples of homœopathic cures performed unintentionally by physicians of the old school of medicine:—

The author of the fifth book, 'Επιδημιῶν, attributed to Hippocrates, speaks of a patient attacked by the most violent cholera, and who was cured solely by white hellebore; which according to the observations of Forestus, Ledelius, Reimann, and many others, produces of itself a kind of cholera. The English sweating sickness of 1415, which was so fatal that it killed 99 out of 100 affected with it, could only be cured by the use of sudorifics. Dysentery is sometimes cured by purgatives. Tobacco, which causes giddiness, nausea, &c., has been found to relieve these affections. Colchicum cures dropsy, because it diminishes the secretion of urine, and causes asthma in consequence of exciting dyspnœa. Jalap creates gripes; therefore it allays the gripes, which are so frequent in young children. Senna occasions colic; therefore it cures this disease. Ipecacuanha is effectual in dysentery and asthma, because it possesses the power of exciting hemorrhage and asthma. Belladonna produces difficult respiration, burning thirst, a sense of choking, together with a horror of liquids when brought near the patient; a flushed countenance, eyes fixed and sparkling, and an eager desire to snap at the bystanders; in short, a perfect image of that sort of hydrophobia which Sir Theodore de Mayerne, Münch, Buchholz, and Neimicke, assert they have completely cured by the use of this plant. When, indeed, belladonna fails to cure canine madness, it is attributable, according to Hahnemann, either to the remedy having been given in too large doses, or to some variation in the symptoms of the particular case, which required a different specific—perhaps hyoscyamus, or stramonium. Drs. Hartlaub and Trinks have subsequently added another homœopathic remedy for hydrophobia—namely, cantharides. Opium cures lethargy and stupor, by converting it into a natural sleep. The same substance is a cure for constipation. Vaccination is a protection from small-pox, on homœopathic principles. The best application to frost-bitten parts is cold, either by the use of some freezing mixture, or by rubbing the part with snow. In burns or scalds the best means of relief are the exposure of the part to heat, or the application of heated spirit of wine or oil of turpentine.

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[1] Hahnemann, *Organon,* § lxi.

[2] See the *Preface to the English Translation of the "Organon."*

Hahnemann thinks that it is of little importance to endeavour to elucidate, in a scientific manner, how the homœopathic remedy effects a cure; but he offers the following as a probable explanation. The medicine sets up, in the suffering part of the organism, an artificial but somewhat stronger disease, which, on account of its great similarity and preponderating influence, takes the place of the former; and the organism from that time forth is affected only by the artificial complaint. This, from the minute dose of the medicine used, soon subsides, and leaves the patient altogether free from disease; that is to say, permanently cured. As the secondary effects of medicines are always injurious, it is very necessary to use no larger doses than are absolutely requisite, more especially as the effects do not decrease in proportion to the diminution of the dose. Thus eight drops of a medicinal tincture do not produce four times the effects of two drops, but only twice: hence he uses exceedingly small doses of medicines. Proceeding gradually in his reductions, he has brought his doses down to an exiguity before unheard of, and seemingly incredible. The millionth part of a grain of many substances is an ordinary dose; but the reduction proceeds to a billionth, a trillionth, nay, to the decillionth of a grain, and the whole materia medica may be carried in the waistcoat-pocket!

The following is the method of obtaining these small doses:—Suppose the substance to be a solid; reduce it to powder, and mix one grain of it with ninety-nine grains of sugar of milk: this constitutes the *first attenuation.* To obtain the *second attenuation,* mix one grain of the first attenuation with a hundred grains of sugar of milk. The *third attenuation* is procured by mixing one grain of the second attenuation with ninety-nine grains of sugar of milk. In this way he proceeds until he arrives at the *thirtieth attenuation.* Water is the diluent for liquid medicines. The following table shows the strength of the different attenuations, with the signs he employs to distinguish them:—

Attenuations.	*Parts of a Grain.*
1. First	One-hundredth.
2. Second	One-thousandth.
I. Third	One-millionth.
II. Sixth	One-billionth.
III. Ninth	One-trillionth.
IV. Twelfth	One-quadrillionth.
V. Fifteenth	One-quintillionth.
VI. Eighteenth	One-sextillionth.
VII. Twenty-first	One-septillionth.
VIII. Twenty-fourth	One-octillionth.
IX. Twenty-seventh	One-nonillionth.
X. Thirteenth	One-decillionth.

Here is a tabular view of the doses of some substances employed by the homœopathists:—

Charcoal, one or two decillionths of a grain.
Chamomile, two quadrillionths of a grain.
Nutmeg, two millionths of a grain.
Tartar emetic, two billionths of a grain.
Opium, two decillionths of a drop of a spirituous solution.
Arsenious acid, one or two decillionths of a grain.
Ipecacuanha, two or three millionths of a grain.

These doses are given in pills (*globuli*), each about the size of a poppy-seed.

Hahnemann gravely asserts, that the length of time a powder is rubbed, or the number of shakes we give to a mixture, influences the effect on the body.

Rubbing or shaking is so energetic in developing the inherent virtues of medicines, that latterly, says Hahnemann, "I have been forced, by experience, to reduce the number of shakes to two, of which I formerly prescribed ten to each dilution[1]." In mixing a powder with sugar, the exact period we are to rub is, therefore, laid down; and in dissolving a solid in water, we are told to move the phial "*circa axin suam*," and at each attenuation to shake it *twice*—"*bis, brachio quidem bis moto, concute*[2]."

The principal facts to be urged against this doctrine may be reduced to four heads:—

1st. Some of our best and most certain medicines cannot be regarded as homœopathic: thus substances which destroy the itch-insect (Acarus Scabiei), and thereby cure the itch, are incapable of producing this malady. Andral took quina in the requisite quantity, but without acquiring intermittent fever; yet no person can doubt the fact of the great benefit frequently derived from the employment of this agent in ague; the paroxysms cease, and the patient seems cured. "But," says Hahnemann, "are the poor patients really cured in these cases?" All that can be said is, that they seem to be so; but it would appear, according to this homœopathist, that patients do not know when they are well. We are also told, that whenever an intermittent resembles the effects of cinchona, then, and not till then, can we expect a cure. I am afraid, if this were true, very few agues could be cured.

2dly. In many cases homœopathic remedies would only increase the original disease; and we can readily imagine the ill effects which would arise from the exhibition of acrids in gastritis, or of cantharides in acute inflammation of the bladder, or of mercury in salivation.

3dly. The doses in which these agents are exhibited are so exceedingly small, that it is difficult to believe they can produce any effect on the system[3], and we may infer that the supposed homœopathic cures are referable to a natural and spontaneous cure, aided, in many cases, by a strict attention to diet and regimen. What effect can be expected from a decillionth part of a drop of laudanum, or a millionth of a grain of charcoal? Hahnemann says, it is foolish to doubt the possibility of that which really occurs; and adds, that the sceptics do not consider the rubbing and shaking bestowed upon the homœopathic preparation, by which it acquires a wonderful development of power!

4thly. Homœopathy has been fairly put to the test of experiment by some of the members of the *Académie de Médecine*, and the result was a failure. Andral tried it on 130 or 140 patients, in the presence of the homœopathists themselves, adopting every requisite care and precaution, yet in not one instance was he successful[4].

3. *Allopathia.*—The *allopathic* (so called from ἄλλος, *another*, and πάθος, *a disease*,) or *heteropathic* method consists in the employment of medicines which give rise to phenomena altogether different or foreign (neither similar nor exactly opposite) to those of the disease.

Under this head is included that mode of cure effected by what is called *antagonism* or *counter-irritation*; that is, the production of an artificial or secondary disease in order to relieve another or primary one. It is a method of treatment derived from observation of the influence which maladies mutually exert over each other. For example, it has been frequently noticed, that if a diarrhœa come on during the progress of some internal diseases, the latter are often ameliorated, or perhaps rapidly disappear, apparently in consequence of the secondary affection. The result of observations of this kind would naturally be the employment of alvine evacuants in other analogous cases where diarrhœa did not spontaneously take place: and this practice is frequently attended with beneficial results. The appearance of a cutaneous eruption is sometimes the signal for the disappearance of an internal affection; and *vice versâ*, the disappearance of a cutaneous disease is sometimes followed by disorder of internal organs. . Here we have another remedy suggested, namely, the production of an artificial disease of the skin, as by blisters, by an ointment containing emetic tartar, or by other irritating applications,—a suggestion, the advantage of which experience has frequently verified. I might bring forward numerous other examples to prove the fact (which, however, is so well known as to require little proof), that morbid action in one part will often cease in consequence of a morbid action taking place in another. Diseases, then, appear to have what Dr. Pring[1] calls a *curative relation* with respect to each other; and we shall find that the greater part of our most valuable and certain remedies operate on the principle of antagonism or counter-irritation; that is, they produce a secondary disease which is related to the primary one. Dr. Parry[2] calls this the "*cure of diseases by conversion.*"

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[1] *Organon.*

[2] See Dr. Quin's *Pharmacopœia Homœopathica.*

[3] The statements of the homœopathists with regard to the effects of medicines are truly absurd and ridiculous. In the French edition of Hahnemann's Materia Medica, no less than forty-five octavo pages are devoted to the statement of 720 symptoms produced by the one-millionth of a grain of vegetable charcoal, and of 190 symptoms caused by the like quantity of animal charcoal. Among the many effects ascribed to these agents we find "itching of the internal angle of the left eye," "itching in a wart on the finger," "repugnance for butter," "obstruction of the left nostril for an hour," "speedy loss of appetite by eating," &c. &c. Many of the observations are filthy and obscene.

[4] See *Medical Gazette*, vol. xv. p. 922.

Mr. Hunter says, he has seen bubo cured by an emetic. Now, it is very improbable that the benefit arose from the mere evacuation of the contents of the stomach. The only plausible explanation to be offered, is, that the emetic sets up a new action in the system, which was incompatible with that going on in the groin. If this notion be correct, emetics act as counter-irritants. The efficacy of purgatives, in affections of the head, is best accounted for by supposing that they operate on the principle of counter-irritation. Blisters, cauteries, issues, moxa, and other remedies of this kind, are generally admitted to have a similar mode of operation. Even the efficacy of blood-letting, in inflammatory affections, is better explained by assuming that this agent induces some new action, incompatible with the morbid action, than that it is merely a debilitant. The immediate effect sometimes produced on disease, by this remedy, is so remarkable as hardly to admit of the supposition of its acting as a mere weakening agent. One full blood-letting will sometimes put an immediate stop to ophthalmia; and I have seen, even while the blood was flowing, the vascularity of the eye diminish, and from that time the disease progressively declined. When to this fact we add, that the same disease is often successfully treated by other different, and even opposite remedies, such as mercury and stimulant applications, we find a difficulty in explaining their beneficial agency, except by supposing that they influence disease by some relation common to all of them. This view of the counter-irritant operation of blood-letting is supported by Dr. Clutterbuck[3], Dr. Pring[4], and others.

Revulsion and *derivation* are both cases of counter-irritation: in the first, the artificial or secondary disease is produced in a part remote from the seat of the primary affection; in the latter, the artificial disease is set up in the neighbourhood of the primary malady. For example, leeches or blisters applied to the feet in apoplexy are called revulsives; but the same applications to the head, in the same disease, would be termed derivatives. There is, however, no real distinction between them, their operation being similar; for revulsion is only derivation at a distant part.

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[1] *An Exposition of the Principles of Pathology*, p. 352, *et seq.* Lond. 1823.
[2] *Elements of Pathology and Therapeutics*, 2d edit. 1825.
[3] *Lectures on the Theory and Practice of Physic* published in the *Lancet*, vol. x. 1826.
[4] *Op. cit.* pp. 465-8.

Topical applications are frequently counter-irritants. Thus, stimulant washes, applied to the eye, sometimes cure ophthalmia. They operate, apparently, by altering the morbid action, and substituting a milder and more easily cured disease for the one previously existing.

Using the term counter-irritation in its most extended sense, we see our list of agents producing this effect is a most extensive one. It comprehends emetics, purgatives, diffusible stimulants, mercury, blisters, cauteries, issues, setons, moxa, blood-letting (including arteriotomy, venesection, cupping, and leeches), irritating lavements, frictions, sinapisms, rubefacients, the hot and cold baths, and even mental impressions. That is, all these agents excite some action in the system which has a relation (oftentimes beneficial) with the morbid action: to use Dr. Parry's words, these agents cure diseases by *conversion*.

The most unsatisfactory part of the subject is, the theory or hypothesis of the manner in which the mutual relations of diseased actions are effected. Dr. Parry presumes that most diseases consist in local determinations of blood, and that it is a law of the human constitution that excessive morbid determination to two different parts shall not exist in the same person at the same time. Neither of these assumptions, however, is quite correct; but, if both were true, they still leave untouched the question, how determination of blood to one organ is cured by producing a determination to another. To account for it, some assume that the system can produce only a certain quantity of nervous energy, and that as, in every disease, there is an undue or preternatural distribution of nervous energy, so the production of an artificial disease in one part must, by consuming the nervous energy, diminish the disease in another. But the whole hypothesis is grounded on assumptions perfectly gratuitous and incapable of proof. As Dr. Pring justly observes, were this hypothesis true, it would lead us to employ, not bleeding, purgatives, blisters, and all indirect remedies in hepatitis or consumption, but the exercise of the treadmill for a few hours; so that a patient, labouring under phrenitis or pneumonia, should be made to walk fifteen or twenty miles a day, by which, it would be presumed, so much nervous energy would be consumed in the arms and legs, that there could not possibly be any preponderance or excess in any other seat.

Discarding all hypotheses, we must, for the present, be content with the knowledge of the fact, that one disease, whether artificially or spontaneously generated, will often, but not invariably, supersede another of a different kind[1].

a. The *antagonisms* of determinations of blood and of the secretions have been before referred to[2]. Müller[3] states that the antagonism of the secretions is subject to the following laws:—

1. The increase of a secretion in a tissue, *a*, which is less irritable than the organ, *b*, is incapable of producing a diminution in the secretion of the latter; hence, for example, artificially excited secretions from the skin, as by a blister, in the neighbourhood of the

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[1] For further information on this subject, consult Hunter's *Treatise on the Blood, Inflammation, and Gun-shot Wounds*, Lond. 1794; *Dict. des Sciences Médicales*, art. *Révulsion*, by MM. Pinel and Bricheteau; *Dict. de Médecine*, art. *Derivatif*, by Guersent; J. C. Sabatier, *Les Lois de la Révulsion, étudiées sous le Rapport Physiologique et Thérapeutique*, Paris, 1832.

[2] See p. 12.

[3] *Elements of Physiology*, by Baly, vol. i. p. 473-4.

eye, in inflammation of the latter organ, are of no service, because the eye is a more irritable part than the skin.

2. An increased secretion in a certain tissue, *a*, cannot be diminished by exciting the same secretion in another part of the same tissue, *a*; on the contrary, such a procedure would rather increase the secretion from all parts of the tissue than diminish it, because the relation which exists between the different parts of one and the same tissue is that of sympathy, not of antagonism. Hence, a discharge from the generative or urinary organs cannot be arrested by an artificially excited diarrhœa.

3. On the contrary, the secretions of tissues which do not belong to the same class of structures, often antagonize each other. Thus, increase of the cutaneous secretion frequently induces diminution of the secretion of the kidneys: in summer, the cutaneous exhalation is more abundant, and the urinary secretion proportionally scanty; in winter, the reverse is the case. Effusion of watery fluids into the cellular membrane and serous cavities is attended with dryness of the skin, and diminution of the urinary secretion, the quantity of which is observed to increase in the same proportion as dropsical effusions diminish. Suppression of the exhalation of the skin by cold, gives rise to mucous discharges from the intestinal and pulmonary mucous membranes.

4. It is only towards the termination of consumptive diseases that this relation of antagonism between the secretion ceases to exist; when, in consequence of the relaxed state of the tissues, all are at length increased in quantity; in the colliquative state that precedes death in phthisical patients, colliquative diarrhœa, profuse sweating, and dropsical effusions, take place simultaneously.

5. When one tissue is excited to increased action, by an impression made upon another, either the secretion of the two must have been in some respects similar, as in the case of the skin and kidneys, both of which have the office of excreting water from the blood; or the organ thus excited must have had a predisposition to morbid action, which is the rational explanation for the circumstance, that the impression of cold produces in one person an affection of the mucous membrane of the lungs; in another, a disordered secretion of mucus in the intestinal canal.

6. Parts to which Medicines are Applied.

Medicines are applied to the skin; to mucous or serous membranes; to wounds, ulcers, or abscessess; or they are injected into the veins.

1. *Applications to the Skin.*

Medicinal applications are frequently made to the skin in order to produce local effects, as in the case of blisters, cataplasms, fomentations, lotions, embrocations, &c.; and occasionally to affect remote parts of the system, as when we use mercury. Most, if not all, medicines which influence distant organs by application to the skin, do so in consequence of their absorption; and, as the cuticle offers a mechanical impediment to this process, we generally either remove it or make use of friction.

There are three methods of applying medicines to the skin; namely, the *enepidermic*, the *iatraleptic*, and the *endermic*.

1. The Enepidermic Method consists in the application of medicines to the skin, unassisted by friction; as when we employ plasters, blisters, poultices, lotions, fomentations, baths, &c.

2. The Iatraleptic Method (which has been so called from ἰατρεύω, *I cure* or *heal*, and 'αλείφω, *I anoint*), consists in the application of medicines to the skin, aided by friction. It has been termed the *epidermic method*—sometimes *anatripsologia* (from ἀνατρίβω, *I rub in*, and λόγος, *a discourse*), and also *espnoïc medicine*. It was employed by Hippocrates, and other old writers; but fell into disuse, until attention was again drawn to it by Brera,

Chiarenti, Chrestien[1], and others. Among the substances which have been employed in this way are camphor, digitalis, squills, cantharides, disulphate of quina, veratria, colocynth, rhubarb, opium, belladonna, mercury, chloride of gold, &c.

The mode of employing medicinal agents, according to the iatraleptic method, is the following: the substance to be applied being reduced to the finest possible state of division, is to be dissolved or suspended in some appropriate liquid, and in this state rubbed into the skin. The dose is always considerably larger than for the stomach—generally two or three, often as much as ten, and, in some cases, even twenty times the ordinary dose: but no absolute rule on this head can be laid down. The liquids employed to dissolve or suspend the medicine may be water, spirit, or oily or fatty matter. Iatraleptic writers, however, prefer the gastric juice, or saliva, or even bile; but I am not acquainted with any just grounds for this preference. Collard de Martigny[2] concludes from his experiments, that the palms of the hands, soles of the feet, neighbourhood of the joints, the chest, the back, and the inner parts of the limbs, are to be preferred for the application of medicines.

The objections to this mode of employing medicines are the uncertainty of results; the time required to affect the system; the frequently unpleasant nature of the process (as when mercurial inunctions are employed); and the local irritation sometimes produced by the friction. Notwithstanding these, however, it may be resorted to occasionally with advantage; as where the patient cannot or will not swallow, or where the alimentary canal is either very irritable or insensible to the action of medicines.

3. The ENDERMIC, or EMPLASTRO-ENDERMIC METHOD, consists in the application of medicinal agents to the denuded dermis. For its introduction into practice we are indebted to MM. Lembert and Lesieur[3].

The denudation of the dermis is usually effected by a blistering plaster. When the cuticle is elevated, an opening is to be made into it, in order to allow the serum to escape. The medicine is then applied to the dermis, either with or without removing the cuticle. At the first dressing, the transparent pellicle formed by the dermis is to be carefully removed, as it very much impedes absorption. The medicine is applied to the denuded surface, either in its pure state, in the form of an impalpable powder—or if too irritating, it is to be incorporated with gelatine, lard, or cerate. Should any circumstances arise to lead us to fear that the quantity of the medicine applied has been too large, the mode of proceeding is the following:—Cleanse the surface immediately; make compression (as by a cupping-glass) around the denuded part, in order to prevent absorption, and apply any substance that will neutralize the effect of the medicine. Thus, Lembert has found, that two grains of the acetate of morphia will destroy the tetanic symptoms caused by the application of two grains of strychnia. Musk and camphor are said to counteract the narcotism of morphia[4].

Instead of a blistering plaster, Trousseau recommends a vesicating ointment, composed of equal parts of a strong solution of ammonia and lard. Two applications, of five minutes each, are sufficient to raise the cuticle. Boiling water, which has been employed by some persons, is uncertain, painful, and dangerous: it may cause mortification of the dermis, and thus stop absorption.

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[1] *De la Méthode Iatraleptique*, Paris, 1811.

[2] *Dict. de Médec. et de Chirurg. pratiq.* art. *Iatreleptie.*

[3] *Essai sur la Méthode Endermique*, par A. Lembert.

[4] Ahrensen, *Dissert. de Methodo Edermatico*, Hauniæ, 1836—Reviewed in the *Brit. and Foreign Med. Review*, for April 1838, p. 342.

The advantages of the endermic method are, that substances are not submitted to the influence of the digestive process, and their pure effects can be better ascertained;—their operation is in general very quick, and in some cases more rapid than when they are applied to the stomach. If the gastric membrane be inflamed, or if the patient cannot (or will not) swallow, more especially if the case be urgent, this is an admirable method of putting the system under the influence of a medicine.

The disadvantages of the endermic method are, the pain sometimes experienced by the application of medicinal agents to a denuded surface—some even may occasion mortification of the part; the possibility of the skin being permanently marked; lastly, some substances have no effect when used endermically.

The substances which have been used by this method are morphia and its acetate, hydrochlorate, and sulphate, in doses of from a quarter of a grain to two grains; strychnia, from a quarter of a grain to a grain; aconitina, one-sixteenth to one-eighth of a grain; extract of belladonna, three or four grains; disulphate of quina, two to six grains; musk, six or eight grains; tincture of assafœtida, ten minims. Many other agents have also been employed endermically: as digitalis, extract of squills, aloes, saffron, bichloride of mercury, emetic tartar, &c.[1]

Method by Inoculation.—In connection with the endermic method may be mentioned another mode of employing medicines; namely, the method by inoculation proposed by M. Lasargue de St. Emilion[2]. In this way morphia has been employed to relieve topical pain. It is introduced in the part in pain by the point of a lancet. In a few minutes a pimple and an erythematons blush are produced.

2. *Applications to the Mucous Membranes.*

We have two mucous membranes, to the different parts of each of which we apply medicines: the first is *the gastro-pulmonary membrane,* the second *the urino-genital.*

1. *Gastro-pulmonary Membrane.*

- *a.* Ocular mucous membrane (conjunctiva).
- *b.* Nasal or pituitary membrane.
- *c.* Bucco-guttural membrane.
- *d.* Eustachian membrane.
- *e.* Aërian or tracheo-bronchial membrane.
- *f.* Gastro-intestinal membrane.
- *g.* Recto-colic membrane.

2. *Urino-genital Membrane.*

- *a.* Urethro-vesical membrane.
- *b.* Vagino-uterine membrane.

1. GASTRO-PULMONARY MEMBRANE: *a. Ocular mucous membrane* or *conjunctiva.*—Medicines are applied to the conjunctiva, to excite local effects only, though we might employ this part for other purposes, since remote organs may be affected by it. The term *collyrium,* (κόλλύριον) formerly

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[1] For further information on the endermic method, consullt, besides Lembert's Essay before quoted, the article *Endermique Méthode*, by Bouillaud, in the *Dict. de Médec. et Chirurg. pratiques;* also some articles, by Dr. Bureaud Riofrey, in the *Continental and British Medical Review*, vol. i. pp. 66, 321, and 385; and Richter, in *Lond. Med. Gaz.* Nov. 10, 1838.

[2] See the *Continental and British Review,* vol. i. pp. 41 and 388; and *Lancet*, for 1836-37, vol. i. p. 826.

employed to indicate solid substances applied to the eyes, now usually means liquid washes for the eyes, and is equivalent to *eyewater*.

b. Nasal or *pituitary membrane.*—We seldom apply medicines to the *pituitary* membrane except in affections of the nose or adjacent parts. Sometimes they are employed to irritate and excite a discharge; they are then called *errhines*; but when used to produce sneezing, as when foreign bodies are in the nasal cavities, they are termed *sternutatories* or *ptarmics*.

c. Bucco-guttural mucous membrane.—Medicines are very rarely applied to the *mouth* and *throat*, except for local purposes. It, however, has been proposed to excite salivation by rubbing calomel into the gums. Solids used in the mouth are termed *lozenges* (*trochischi*) or *masticatories*, according as they are allowed to dissolve slowly or are masticated; liquids are called *collutoria* or *gargarismata*. Powders are introduced by insufflation.

d. Eustachian membrane.—Aurists now and then apply washes to the *Eustachian tubes* in local affections; but the occasions for this practice are rare, and the operation difficult, except in practised hands.

e. Aërial or *tracheo-bronchial membrane.*—Accidental observation, as well as experiment, has shewn that medicines produce very powerful effects on the membrane lining the *trachea* and *bronchial tubes*. Applications to these parts are in general made use of for local purposes, as in asthma, chronic bronchitis, phthisis, &c., though occasionally to affect the brain, the blood, the heart, &c. Dr. Myddleton[1] advocated the inhalation of substances (as cinchona, sulphate of iron, myrrh, &c.) reduced to an impalpable powder in pulmonary diseases. The fumes (*suffitus*) of tar, balsam, resins, and other burning bodies, have also been employed in these cases[2].

The inhalation of aqueous vapour (*halitus*), either alone or with other substances, is oftentimes useful in various affections of the lungs and of the throat, &c. The apparatus generally used for this purpose is Dr. Mudge's inhaler, or it may be that proposed by Dr. Gairdner[3]. In the absence of these, a teapot, or basin with an inverted funnel, is often employed; but in many asthmatic cases the difficulty of breathing is so great, that the patient cannot close the mouth around the tube, especially if the latter be small, without exciting a sense of impending suffocation. In such instances I have found the only easy and practical method of enabling the patient to inhale, is by holding the mouth over hot water contained in a basin or teacup. Various narcotic and emollient herbs are sometimes added to the water, but I suspect without contributing in any way to its efficacy. (The methods of inhaling oxygen, chlorine, and nitrous oxide gases, and the vapours of sulphuric ether, iodine, bromine, &c. will be described hereafter).

f. Gastro-intestinal membrane.—We employ both extremities of the *alimentary canal* for the exhibition of medicines; the upper, however, more frequently than the lower. This mode of employing medicines is called the *method by ingestion*. Of all parts of the body, the gastro-intestinal surface is the most useful for the application of medicines. This arises from the great susceptibility, the active absorbing power, and the numerous relations which the stomach has with almost every part of the body. In many cases remote effects are more easily produced by this than by any other organ, as in the case of diffusible stimulants. Medicines which act by absorption are more energetic when applied to the serous membranes, the bronchial membrane, the cellular tissue, &c. In some cases it is not only possible, but probable, that the stomach may either partially or wholly digest a medicine.

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[1] *A Preliminary Dissertation illustrative of a new System of Pulmonary Pathology*, Bath, 1825.

[2] The mode of inhaling tar vapour will be described hereafter (see *Pix liquida*).

[3] *Edinburgh Medical and Surgical Journal*, vol. xix.

g. Recto-colic membrane.—Sometimes, though less frequently than the stomach, the *rectum* is employed for the application of medicines. It has been asserted that the general susceptibility of the rectum is only one-fifth of that of the stomach, and that medicines take five times as long to operate by the former as by the latter: hence it has been said that both the dose, and the interval between the doses, should be five times as great as when applied to the stomach. But this assertion is far from being universally correct, though it may be so occasionally. Orfila asserts that those agents which operate by absorption, as opium and tobacco, are more active by the rectum than by the stomach; and he assigns as a reason the greater venous absorption of the rectum, and its less digestive power. But this statement is in direct opposition to the experience of almost every practitioner. Whenever I have had occasion to employ opium by way of enema, I always exhibit twice or three times the ordinary dose, without exciting any remarkable effects. Dr. Christison states that he has given two measured drachms of laudanum by injection, without producing more than usual somnolency; a quantity which, if Orfila's statement were correct, would probably prove fatal.

We apply medicines to the rectum, sometimes with the view of alleviating disease of this or of neighbouring organs (as of the uterus, bladder, prostate gland, &c.); at other times in order to irritate the rectum, and, on the principle of counter-irritation, to relieve distant parts (as the head); sometimes to produce alvine evacuations, or to dissolve hardened fæces; occasionally, also, when we are precluded from applying our remedies to the stomach, on account of their unpleasant taste and smell, the inability or indisposition of the patient to swallow, or the irritability of the stomach; and, lastly, in order to destroy the small thread-worm (*Ascaris vermicularis*).

When the substances applied to the rectum are solid, we name them *suppositories* (*suppositoria*, from *suppono*, to put under); but when of a fluid nature, they are termed *clysters*, *lavements*, or *enemata*.

Formerly *suppositories* were conical, or cylindrical, like a candle, and of variable size,—sometimes one or two inches long. They are now usually made globular, and of small size. They are employed to evacuate the bowels; to irritate the rectum, and thereby to relieve affections of distant organs; but more commonly to act as local agents in affections of the rectum, bladder, uterus, prostate gland, urethra, &c. A mixture of opium and soap is frequently employed with advantage, to prevent the pain of priapism during the night, in gonorrhœa[1].

Clysters or *lavements* require to be considered under several points of view: *first*, in reference to the material of which they are made, and which must vary with the object for which these remedies are employed; *secondly*, with res t to the quantity of liquid used, and which will depend on the age of the ent. The average quantity for an adult is about twelve or sixteen ounces nd I believe that it is rarely proper to use more than this. I am su hat the practice of introducing several pints of fluid into the large intesti with the view of exciting alvine evacuations, is bad. In the first place it often provokes the contraction of the gut, by which the injection is immediately returned; and, secondly, repeated distension diminishes the susceptibility of the part, so that the ordinary accumulation of fæcal matter no longer acts as a sufficient stimulus. Mr. Salmon[1] has related a case of this kind, where the patient had nearly lost all power of relieving the bowels, except by enemata or purgatives, and had produced dilatation of the rectum, in consequence of having been in the habit of introducing into the intestine two quarts of gruel twice every day. A newly-born infant requires about one fluidounce; a child of one to five years, from three to four ounces; and a youth from ten to fifteen, from six to eight fluidounces. *Thirdly*, the impulse with which the fluid ought to be thrown up, deserves attention. If too much force be used, the sudden dilatation of the gut may bring on spasmodic action of its lower part, by which the clyster will be returned. *Fourthly*, the instruments by which the injection is effected, require notice. The common pipe and bladder are too well known to require description. I am inclined to think that the most convenient, safe, and useful apparatus, is the elastic bottle and tube. Any quantity of liquid, however small, may be thrown up with the greatest ease, and without any danger of the impulse being too great. Its application is exceedingly convenient; a lusty person, by placing one foot on a stool or chair, may easily apply it without assistance; and its price is very moderate. Another form of enema apparatus is a narrow water-proof tube, holding about a pint of liquid, about four feet long, narrower at one end, which is furnished with a common injecting pipe, and about two and a half inches in diameter at the other. The fluid being placed in the tube, the pipe is introduced into the rectum, and the apparatus held in a perpendicular direction, by which the fluid is propelled into the gut by its own gravity.

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[1] me remarks on Suppositories, by Dr. O borne, see *London Medical Gazette*, March 6, 1840.

Gaseous matters have been sometimes thrown into the rectum. Thus the injection of common air has been proposed in ileus[2]; tobacco-smoke has been employed in hernia; and carbonic acid gas in ulceration of the rectum.

2. URINO-GENITAL MEMBRANE. *a. Urethro-vesical membrane.*—Applications to the *urethra* are made only for local purposes; either in a solid form, as caustic or medicated bougies, or in that of a liquid, as an injection: the latter is easily applied by a common syringe.

Injections are sometimes thrown into the *bladder*, but always for local purposes. The operation is easily performed by attaching a catheter to an elastic bottle.

b. Vagino-uterine membrane.—Medicines are applied to the *vagina* and *uterus*, to produce local effects only. Thus injections are made to relieve vaginal discharges, to excite the catamenia, &c. They are usually liquids, but in a case related to me by my friend, Dr. Clutterbuck, carbonic acid gas was successfully employed to relieve an irritable uterus.

3. *Applications to the Serous Membranes.*

a. Tunica vaginalis.—Irritating injections, such as wine and water, solutions of metallic salts, &c. are thrown into the cavity of the serous membrane of the testicle in hydrocele, in order to excite inflammation and the subsequent adhesion of the sides of the sac.

b. Peritoneum.—Injections have also been made into the peritoneal sac in ascites, and in some cases with success[1]. The practice, however, is very dangerous. Mr. Cooper[2] has seen two fatal cases of it.

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[1] *Practical Essay on Prolapsus of the Rectum*, p. 24, Lond. 1831.

[2] *Edinburgh Medical and Surgical Journal*, vol. xvi.

4. *Applications to Ulcers, Wounds, and Abscesses.*

These are employed principally to excite local effects, and sometimes, though rarely, to produce a constitutional affection. Thus it has been proposed to apply corrosive sublimate to wounds, with the view of causing salivation.

5. *Injection of Medicines into the Veins.*

(Chirurgia infusoria; Ars clysmatica nova; Infusion of medicines.)

This history of this operation is inseparably connected with that of *transfusion*. The first experiments on infusion are said to have been performed in Germany[3]. But the first scientific examination of the operation was made by Sir Christopher Wren[4]. His example was followed by Boyle, Clarke, Henshaw, Lower, and others[5].

The partisans of this method of treatment assert, that when medicines are administered by the stomach, their properties are more or less altered by the digestive powers of this viscus; and that by injecting medicines at once into the veins, we avoid this influence. The effects are of the same general nature as when medicines are applied to the skin or stomach: thus emetic tartar occasions vomiting, senna purges, opium stupifies, and so on. So that some of the supposed advantages of this operation have no real existence, while several objections to it exist: such as the danger of introducing air into the veins, or of throwing in too large a dose of the remedy (for a slight excess in some cases may prove fatal), or of the occurrence of phlebitis. These, then, are sufficient reasons for not resorting to this practice, except on very urgent occasions; for example, to excite speedy vomiting when the patent is unable to swallow. Köhler (mentioned by Dieffenbach, who notices also several other analogous cases) preserved the life of a soldier, in whose throat a piece of beef tendon was sticking, by throwing a solution of six grains of emetic tartar into a vein of the arm: vomiting was induced, and the meat expelled. Meckel injected two grains of this salt, dissolved in water, into the veins of a woman, to restore suspended animation from immersion in water. Lastly, cold water has been injected into the umbilical vein in cases of retained placenta[6].

In some obstinate and dangerous diseases this operation is admissible as a last resource; for example, in cases of poisoning, in hydrophobia, in malignant cholera, &c. As plethora appears to diminish absorption, it has been proposed to throw tepid water into the venous system in cases of narcotic poisoning, and thus to cause artificial plethora, in order to prevent the occurrence of the symptoms of poisoning by stopping absorption. Vernière found that three grains of nux vomica produced no effect when applied to a wound in a dog, into whose veins water had been thrown; and he asserts, that by the early use of aqueous injections we may prevent the development of contagious diseases. Magendie proposed the injection of tepid water into the veins for the relief of hydrophobia. The operation was first performed at the Hôtel-Dieu, at Paris, in October, 1823; the convulsions were stopped, but the patient died in a day or two afterwards. This operation has been several times repeated, and with the same results. In June, 1832, I tried it on a patient (afflicted with this terrible disease) under the care of the late Mr. Bennett, of the Commercial Road: the patient was a boy about nine years of age; he was nearly insensible at the time I performed the operation. I threw in about one quart of tepid water without any obvious effect on the pulse: no convulsions were subsequently observed, but the patient died in a few hours. Saline solutions were injected into the veins in malignant cholera, and often with apparent advantage (see the article on *Sodii Chloridum*). Purgatives, narcotics, &c. have been thrown into the veins by different physiologists, and in most cases the effects observed were similar to, though more powerful than, those produced when these agents were administered by the stomach. To this statement, however, the oils are an exception; for when injected into the veins in large quantities they interrupt the circulation, and produce a kind of asphyxia.

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[1] *Philosophical Transactions* for the year 1744.

[2] *Dictionary of Practical Surgery*, art. *Paracentesis*.

[3] See Paul Scheel's work, entitled "*Die Transfusion des Bluts und Einsprützung der Arzneyen in die Adern*," Kopenhagen, 1802: Zweiter Band, 1803.

[4] *Philosophical Transactions* for 1665, vol. i. p. 131.

[5] For further information on the history of this operation, consult Scheel's work, before quoted; also Dieffenbach's essay, "*Ueber die Transfusion des Bluts und die Infusion der Arzneien*," 1833; or Marx's "*Die Lehre von den Giften*," 1827 and 1829.

[6] *British and Foreign Medical Review*, Jan. 1837, and Jan. 1838.

7. On the Classification of Medicines.

In some works on medical botany, which contain figures of the plants employed in medicine, the authors have not followed any arrangement, in consequence, I presume, of the impossibility of procuring specimens in regular order. This is the case in the following works:—

W. Woodville, M.D.—Medical Botany, 3 vols. 4to. London, 1790.—A Supplement to the Medical Botany, 4to. London, 1794. [In the second edition of this work, published in 1810, the subjects were arranged according to their natural orders.—The third edition, in 1832, by Dr. Hooker and Mr. Spratt, was, in fact, the second edition with a new title and an additional volume.]

J. Bigelow, M.D.—American Medical Botany, 3 vols. 8vo. Boston, 1817-18-20.

W. P. C. Barton, M.D.—Vegetable Materia Medica of the United States, 2 vols. 4to. Philadelphia, 1818.

J. Stephenson, M.D. and *J. M. Churchill*.—Medical Botany, 4 vols. 8vo. London, 1827-31.—2d ed. in 3 vols., by G. Burnett, 1834-36.

Flora Medica, 2 vols. 8vo. 1827.

The large number of substances employed in the treatment of diseases renders some arrangement of them almost absolutely necessary;—and I conceive any order of treating them to be better than none.

Arrangements or classifications of medicines, like those of plants[1], may be divided into *empirical* and *rational* ones.

1. *Empirical Arrangements.*

These are independent of the nature of, and have no real relation or connection with, the substances to be arranged. An *alphabetical* order, since it is founded on names which are arbitrary and have no relation to the bodies they are intended to designate, is of this kind. Two advantages have been supposed to be gained by its employment: firstly, a ready reference to any particular substance; and, secondly, the avoidance of errors committed by writers who adopt other methods. But the first is more imaginary than real; for an index gives to any mode of classification every advantage derived from an alphabetical arrangement: and, as each substance is known by a variety of names, an index becomes as necessary to an alphabetical as to any other method. Like other classifications, this has its disadvantages, the most important of which are, that it brings together substances of the most incongruous natures, and separates those which agree in most of their properties; and from its want of order, it distracts the attention of the student, and is, therefore, totally unfitted for an elementary work.

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[1] *Théorie Elémentaire de la Botanique*, par A. P. De Candolle, Paris, 1819.

The following are some of the more important works in which medicines are described in an alphabetical order:—

M. de la Beyrie and *M. Goulin*—Dictionnaire raisonné-universel de Matière Médicale, t. viii. Paris, 1773.
J. Rutty—Mat. Medica antiqua et nova, repurgata et illustrata, 4to. Rotterodami, 1775.
W. Lewis—An Experimental History of the Materia Medica, 4to. 1761.—4th edition, by Dr. Aikin, 2 vols. 8vo. 1791.
Andrew Duncan, jun. M.D.—The Edinburgh New Dispensatory, 11th edit. Edinburgh, 1826.—Supplement to the above. 1829.
J. R. Coxe, M.D.—The American Dispensatory. Philadelphia, 1826.
J. Thacher, M.D.—The American New Dispensatory. Boston, 1810.—2d edition. 1813.
A. T. Thomson, M.D.—The London Dispensatory. London, 1811.—10th edition. 1844.
J. A. Paris, M.D.—Pharmacologia, 3d edition, 1820.—8th edition, 1833.—App. 1838.
W. Ainslie, M.D.—Materia Indica, 2 vols. London, 1826.
W. T. Brande—A Manual of Pharmacy. London, 1825.—3d edition. 1833.
A. Chevallier, *A. Richard*, and *J. A. Guillemin*—Dictionnaire des Drogues simples et composées, tom. v. Paris, 1827-9.
F. P. Dulk—Die Preussische Pharmakopöe, übersetz und erläutert, 2te Aufl. 2 Th. 8vo. Leipsig, 1830.
L. Martinet—Manuel de Thérapeutique et de Matière Médicale. Paris, 1828.
F. S. Ratier—Traité élémentaire de Matière Médicale, tom. ii. Paris, 1829.
F. V. Mérat et *A. J. De Lens*—Dictionnaire universel de Matière Médicale et de Thérapeutique Générale, tom. vi. 1829-34.—Tom. vii., Supplement. 1846.
L. W. Sachs and *F. P. Dulk*—Handwörterbuch der praktischen Arzneimittellehre, 19 Lief. A—St. Königsberg, 1830-37.
G. B. Wood, M.D. and *F. Bache*, M.D.—The Dispensatory of the United States of America. 1833.—3d edition. 1836.—5th edition. 1843.
Bachmann, W. L.—Handwörterbuch der praktischen Apothekerkunst, 2 Bde. Nürnberg, 1837.
A. Ure, M.D.—A Practical Compendium of the Materia Medica, with numerous Formulæ for the Treatment of Diseases of Infancy and Childhood. London, 1838.
E. Winkler—Vollständiges Real Lexicon der medicinisch-pharmaceutischen Naturgeschicte und Rohwaarenkunde, 8vo. Leipzig, 1838-42.
W. T. Brande—A Dictionary of Materia Medica and Practical Pharmacy, 8vo London, 1839.
R. Christison, M.D.—A Dispensatory, or Commentary on the Pharmacopœias of Great Britain, 8vo. Edinburgh, 1842.
G. F. Most—Encyklopädisches Handwörterbuch der praktischen Arzneimittellehre, 8vo. Rostoch and Schwerin, 1841.
R. Paulus—Taschenwörterbuch der Materia Medica. Unter geigneter Berücksichtigung auch der in neuer Zeit empfohlenen Arzneimittel. Stuttg. 1841.
Martiny Julius und *Dr. Ed.*—Encyklopädie der medicinisch-pharmaceutischen Naturalien und Rohrwaarenkunde, 1er Bd. A—F, 8vo. Quedlinburg und Leipzig, 1843.

2. *Rational Arrangements.*

These have an actual relation with the bodies for which they are used, and are the classifications, properly so called. They are founded on the properties of the substances treated of; consequently are as numerous as there are classes of properties. Thus medicines may be arranged according to their

α. Sensible properties (colour, taste, and smell).
β. Natural-historical properties (external form and structure).
γ. Chemical properties.
δ. Physiological effects.
ε. Therapeutical properties.

a. Classifications founded on the Sensible Qualities.

Classifications founded on the colour, taste, and odour of plants are necessarily very imperfect, owing to the impossibility of defining sensations. Moreover, their use is very limited, in consequence of these properties having no necessary relation to the medicinal powers (see p. 81). In the best executed arrangements of this kind, the denominations of many of the classes, or orders, are objectionable,—dissimilar bodies are brought together, and similar ones separated.

The following writers have offered the best examples of this mode of classification:—

Jon. Osborne, M.D.—On the Indications afforded by the Sensible Qualities of Plants with respect to their Medical Properties. [Contained in the Transactions of the Association of Fellows and Licentiates of the King's and Queen's College of Physicians, vol. v. 1828.

A. F. A. Greeves—An Essay on the Varieties, and Distinctions of Tastes and Smells, and on the Arrangement of the Materia Medica. [Published by *Dr. Duncan*, in his Supplement to the Edinburgh New Dispensatory. 1829.]

MR. GREEVES' CLASSIFICATION.

CLASSES.	FAMILIES.	ORDERS.	EXAMPLES.
I. INODOROUS AND INSIPID	1. *Liquid*	1.	Water.
	2. *Soft*	1. Pulverescent	Creta.
		2. Unctuous	White Wax.
	3. *Hard*	1. Tough	Iron.
		2. Brittle	Antimony.
II. INODOROUS AND SAPID	1. *Sweets*	1. Saccharine	Sugar.
		2. Amylaceous	Starch.
		3. Mucous or Unctuous	Gum.
		4. Faint	Castor Oil.
		5. Frugous	Tamarinds.
	2. *Bitters*	1. Mawkish	Elaterium.
		2. Astringent	Catechu and Alum.
		3. Pure bitter	Quassia.
		4. Austere	Galls.
		5. Styptic	Sulphate of Copper.
		6. Acrid	Colchicum.
		7. Salino-amaro	Nitre.
	3. *Alkalines*	1.	Potash.
	4. *Acids*	1. Pure acid	Citric Acid.
		2. Saccharo-acid	Orange Juice.
	5. *Salines*	1. Pure Salt	Common Salt.
III. ODOROUS AND INSIPID	1. *Fragrant*	1. Sweet	Yellow Wax.
		2. Aromatic	Saunder's Wood.
IV. ODOROUS AND SAPID	1. *Sweets*	1. Saccharine	Honey.
		2. Faint	Senna.
		3. Sweet-spicy	Caraway.
	2. *Bitters*	1. Mawkish	Jalap.
		2. Subastringent	Rhubarb.
		3. Bitter-spicy	Cascarilla.
		4. Sharp-bitter	Aloes.
		5. Austere	Cinchona.
		6. Subacrid	Ipecacuanha and Musk.
		7. Acrid	Copaiba.
	3. *Acidous*	1.	Acetum.
	4. *Camphreous*	1. Camphreous aromatics	Cloves.
		2. Savoury	Pepper.
		3. Terebinthinate	Turpentine.
		4. Camphreous	Camphor.
	5. *Spirituous*	1. Vinous	Wine.
		2.	Alcohol.

β. Classifications founded on the Natural-Historical Properties.

By natural-historical properties, I mean those made use of in natural history. They are principally external form and structure. In living beings we find that peculiar structure denominated *organised*. The structure called *crystalline* is peculiar to mineral and other inorganised bodies.

αα. Vegetables and Animals.

Both the *vegetable* and *animal* materia medica are arranged according to the natural system in the following works:—

J. J. Virey—Histoire Naturelle des Médicamens. Paris, 1820.
A. L. A. Fée—Cours d'Histoire Naturelle pharmaceutique, t. ii. Paris, 1828.
A. Richard—Elémens d'Histoire Naturelle Médicale, t. ii. Paris, 1831.
J. Johnstone, M.D.—A Therapeutic Arrangement and Syllabus of Materia Medica, 12mo. London, 1835.
E. Soubeiran—Nouveau Traité de Pharmacie théorique et pratique, t. ii. Paris, 1836. 2nde édition, 1840.—3e éd. 1847.
S. Dieu—Traité de Matière Médicale et de Thérapeutique, précédé de considérations générales sur la Zoologie, et suivi de l'Histoire des Eaux Naturelles, t. i. and ii. 8vo. Paris, 1847.
Dr. Ed. Ballard and *Dr. A. B. Garrod*—Elements of Materia Medica and Therapeutics, 8vo. London, 1845.
Ph. L. Geiger—Handbuch der Pharmacie.—Pharmaceutische Botanik, 2te Aufl. neu bearbeitet von Dr. T. F. L. Nees von Esenbeck.—Pharmaceutische Zoologie, 2te Aufl. neu bearbeitet von Dr. Cl. Marquart, 8vo. Heidelberg, 1839.
Dr. Cl. Marquart—Lehrbuch der praktischen und theoretischen Pharmacie, 2 vols. 8vo. Mainz. 1844.
Dr. J. F. Royle—A Manual of Materia Medica and Therapeutics, 12mo. Lond. 1847.

As in the subsequent part of this work the vegetable and animal substances used in medicines will be arranged in natural-historical order, it will be unnecessary here to offer any examples illustrative of this classification. I have preferred this mode of arrangement principally on account of the great difficulties attending any other method, especially that founded on the physiological effects of medicines.

ββ. Vegetables only.

In the following works the *vegetable* substances employed in medicine are arranged according to their natural-historical properties:—

J. A. Murray—Apparatus Medicaminum tam simplicium quam præparatorum et compositorum, vol. v. Göttingæ, 1776-89.—Post mortem auctor. edid. *L. C. Althof*, vol. vi. Göttingæ, 1792.
A. P. De Candolle—Essai sur les Propriétés Médicales des Plantes, comparées avec leurs Formes Extérieurs et leur Classification Naturelle, 1804.—2d édition. Paris, 1816.
A. Richard—Botanique Médicale. Paris, 1823.
P. J. Smyttère—Phytologie-pharmaceutique et Médicale. Paris, 1829.
J. H. Dierbach—Abhandlung über die Arzneikräfte der Pflanzen verglichen mit ihrer Structur und ihren chemischen Bestandtheilen. Lemgo, 1831.
T. F. L. Nees von Esenbeck und *C. N. Ebermaier*—Handbuch der medicinisch-pharmaceutischen Botanik, 3 Th. Düsseldorf, 1830-32.
V. Fr. Kosteletzky—Allgemeine medizinisch-pharmazeutische Flora, 6 Bde. Prague, 1831-36.
G. W. Bischoff—Medicinisch-pharmaceutische Botanik. Erl. 1843.
S. Endlicher—Die Medicinal Planzen der österreichischen Pharmakopöe. Ein Handbuch für Aerzte and Apotheker, 8vo. Wien, 1842.
C. F. P. von Martius—Systema Materiæ Medicæ Vegetabilis Brasiliensis. Lipsiæ et Vindeb. 8vo. 1843.

γγ. Animals only.

The *animal* substances used in medicine are arranged in natural-historical order in the following works:—

J. F. Brandt und *J. T. C. Ratzeburg*—Medizinische Zoologie oder, getreue Darstellung und Beschreibung der Thiere, die in der Arzneimittellehre in Betracht kommen in systematischer Folge herausgegeben, 2 Bde. Berlin, 1827-33.
John Stephenson, M.D.—Medical Zoology and Mineralogy. London, 1832.
Dr. T. W. C. Martius—Lehrbuch der pharmaceutischen Zoologie. Stuttgart, 1838.
Dr. Ed. Martiny—Naturgeschichte der für die Heilkunde wichtigen Thiere mit besonderer Rücksicht auf Pharmacologie, Pathologie und Toxicologie, 8vo. Darmstadt, 1847.

δδ. Minerals only.

I am unacquainted with any pharmaceutical work in which the inorganised substances of the materia medica are arranged in natural-historical order. Most writers who have followed the natural system in their descriptions of vegetable and animal medicines, have adopted a chemical classification for the inorganised medicinal substances—a mode of proceeding which I shall follow in this work. In the following works on minerals a natural-historical classification is observed:—

F. Mohs—Treatise on Mineralogy, translated by W. Haidinger, 3 vols. Edinb. 1825.
Robert Allan—Manual of Mineralogy. Edinburgh, 1834.
J. D. Dana—A System of Mineralogy, comprising the most recent Discoveries, 2d edition. New York, 1844.

CRYSTALLOGRAPHICAL CLASSIFICATION OF PHARMACEUTICAL SUBSTANCES.

Modern crystallographers[1] arrange crystalline forms in six groups, called *systems*, each of which comprehends all those forms which agree in the number, length, and direction of the axes. These six systems may be conveniently arranged in two classes, as follows:—

CLASSES.			SYSTEMS.
I. EQUIAXED OR MONOMETRIC			1. The Regular or Cubic.
II. UNEQUIAXED	α. Dimetric	Quadrate	2. The Square Prismatic.
		Hexagonal	3. The Rhombohedric.
	β. Trimetric	Erect	4. The Right Prismatic.
		Oblique	5. The oblique Prismatic.
		Doubly-oblique	6. The Doubly-oblique Primatic.

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[1] For further details, the reader is referred to the following works:—

1. *Elemente der Krystallographie, nebst einer tabellarischen Uebersicht der Mineralien nach den Krystallformen*, von Gustav Rose, Zweite Auflage. Berlin, 1838. [A French translation of the first edition was published in Paris, 1834.)
2. *A Treatise on Crystallography*, by W. H. Miller, M.A. F.R.S. &c. Cambridge, 1839.
3. *A System of Crystallography, with its application to Mineralogy*, by John Joseph Griffin. Glasgow, 1841.
4. *Encyclopædia Metropolitana*, art. *Crystallography*, by Mr. Brooke.
5. *Tabelle über die natürlichen Abtheilungen der verschiedenen Crystallisationssysteme*, nach Prof. C. S. Weiss, für Vorlesungen zusammengestellt und durch Figuren erläutert von Dr. J. T. C. Ratzeburg.
6. *Le Règne Minéral ramené aux Méthodes de l'Histoire Naturelle*, par L. A. Necker, tome 2. Paris, 1835.
7. *Elémentes de Crystallographie*, par M. J. Müller, traduits de l'allemand et annotés par J. Nicklès. Paris, 1847.
8. *Précis de Crystallographie, suivi d'une Méthode simple d'Analyse au Chalumeau, d'après des Leçons particulières* de M. Laurent. Paris, 1847.

CLASS I.—*Equiaxed or Monometric*[1] *Crystals.*

(Isometric[2] Crystals.)

CHARACTERS.—*Geometric:* three rectangular and equal axes. *Optical:* refraction single. *Thermotic:* expansion by heat equal in all directions.

*** As the refraction of this class is single, the crystals present no rings when tested by polarised light.

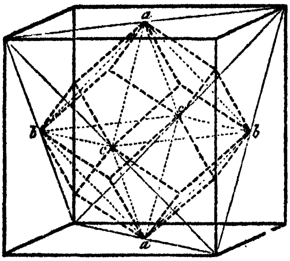
System 1.—The Regular System.

(Tessular system, *Mohs;* Octohedral System, *Miller.* Tetrahedric, Cubic, Equal-membered, or Equal-axed System.

CHARACTERS.—Those of the class.

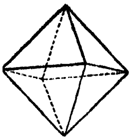
Forms.—To this system belong the *cube*, the *regular octohedron*, the *rhombic dodecahedron*, and the *regular tetrahedron.*

FIG. 17.



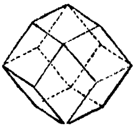
Four forms of the cubic system; viz. cube, regular tetrahedron, rhombic, dodecahedron, *and* regular octohedron.
a a, b b, c c, The three rectangular equal axes.

FIG. 18.



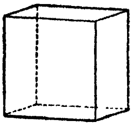
Octohedron.

FIG. 19.



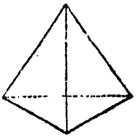
Dodecahedron.

FIG. 20.



Cube.

FIG. 21.



Regular tetrahedron.

EXAMPLES.—The following substances belong to this system:—

Diamond.
Phosphorus.
Potassium.
Sodium.
Bismuth.
Lead.
Cadmium.
Titanium.
Iron.
Copper.
Mercury.
Silver.

Gold.
Platinum.
Arsenious Acid.
Magnetic Oxide of Iron.
Chloride of Ammonium (*Sal Ammoniac*).
Chloride of Potassium.
Chloride of Sodium.
Chloride of Silver.
Iodide of Potassium.
Iodide of Sodium.
Bromide of Potassium.

Bromide of Sodium.
Bromide of Silver.
Fluoride of Calcium.
Sulphuret of Lead (*Galena*).
Sulphuret of Silver.
Bi-sulphuret of Iron (*Mundic*).
Sulphuret of Zinc (*Blende*).
Sulphuret of Tin (*Tin Pyrites*).
Nitrate of Lead.
Nitrate of Baryta.
Nitrate of Strontian.
Alum.

CLASS II.—*Unequiaxed Crystals.*

CHARACTERS.—*Geometric:* not three rectangular and equal axes. *Optical:* refraction double. *Thermotic:* expansion not equal in all directions.

*** As the refraction of this class is double, the crystals present, in certain directions, rings when tested by polarized light.

---

[1] Monometric, from *μόνος, one,* and *μέτρον, a measure*—axes of one kind or measure.
[2] Isometric, from *ἴσος, equal,* and *μέτρον, a measure*—axes equal.

a. Dimetric[1] Crystals.

CHARACTERS.—*Geometric:* axes of two kinds; at least, two equal axes. *Optical:* refraction double in all directions except one (one axis of double refraction). *Thermotic:* expansion equal in two directions at least.

⁂ As the crystals of this sub-class have only one axis of double refraction, they present a single system of rings, intersected by a cross, when placed in the polariscope. (See figs. 22 and 23.)

FIG. 22.

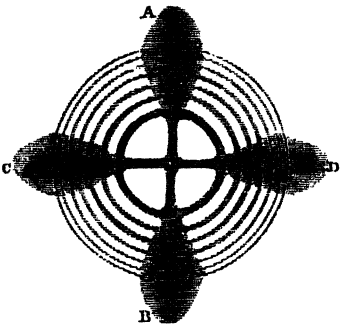
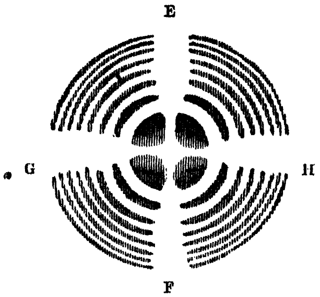


FIG. 23.



Single system of rings seen by looking through a slice of calcareous spar (cut perpendicular to the axis of the crystal) placed in the polariscope.

When the polariser and analyser are at right angles to each other, the cross is a black one (fig. 22, A, B, C, D); but when the positions of the polariser and analyser coincide, the cross is a white one (fig. 23, E, F, G, H).

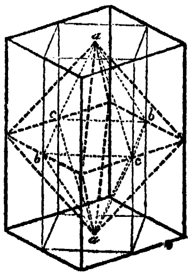
System 2.—Square Prismatic System.

(Pyramidal System, *Mohs* and *Miller*. The 2- and 1-axed System, *Rose*. The 4-membered System.)

CHARACTERS.—*Geometric:* axes three, rectangular; only two equal. *Optical:* refraction double in all directions except one (one axis of double refraction). *Thermotic:* expansion equal in two rectangular directions only.

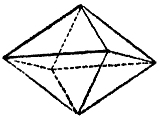
FORMS.—To this system belong the *octohedron with a square base,* and the *right square prism.*

FIG. 24.



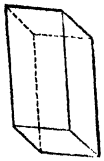
Four forms of the square prismatic system; viz. two square prisms in different positions, *and* two octohedra with square bases.
a a, Principal axis; *b b*, *c c*, secondary axes.

FIG. 25.



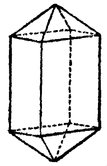
Square octohedron.

FIG. 26.



Square prism.

FIG. 27.



Combination of the octohedron and prism.

---

[1] Dimetric, from δὶς, *twice*, and μέτρον, *a measure*— axes of two kinds.

EXAMPLES.—The following substances belong to this system:—

Peroxide of Tin (*Tin-stone*).
Chloride of Mercury (*Calomel*).
Sulphuret of Copper and Iron (*Copper Pyrites*).
Bicyanide of Mercury.

Ferrocyanide of Potassium.
Acid Triphosphate of Potash and Water.
Acid Triphosphate of Oxide of Ammonium and Water.

Acid Triarseniate of Potash and Water.
Acid Triarseniate of Oxide of Ammonium and Water.

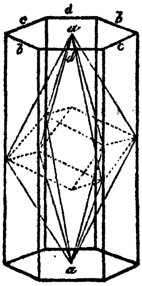
System 3.—Rhombohedric System.

(Rhombohedral System, *Miller*. The 3- and 1-axed System, *Rose*.)

CHARACTERS.—*Geometric:* axes four; three equal to one another, and placed in one plane, crossing at angles of 60°; the fourth axis differs from the others in length, and is perpendicular to them. *Optical:* refraction double in all directions except one (one axis of double refraction). *Thermotic:* expansion equal in the directions of the three equal axes only.

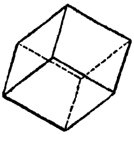
FORMS.—To this system belong the *rhombohedron* (frequently called a rhomboid), the *hexagonal prism*, and the *scalenohedron*.

FIG. 28.



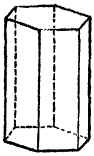
Three forms of the rhombohedric system; viz. the hexagonal prism, the scalene dodecahedron. and the rhombohedron.
a a, The principal axis; *b b*, *c c*, *d d*, secondary axes.

FIG. 29.



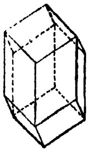
Rhombohedron.

FIG. 30.



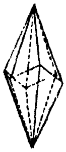
Hexagonal prism.

FIG. 31.



Combination of the rhombohedron with the hexagonal prism.

FIG. 32.



Scalenohedron.

EXAMPLES.—The following substances belong to this system:—

Antimony.
Arsenicum.
Zinc?
Tin?
Plumbago.
Ice.
Oxide of Zinc.
Sesquioxide of Iron (*Specular Iron*).

Sulphuret of Mercury (*Cinnabar*).
Sulphuret of Iron (*Magnetic Pyrites*).
Chloride of Calcium.
Carbonate of Lime (*Calcareous Spar*).
Carbonate of Magnesia (*Magnesite*).

Carbonate of Lime and Magnesia (*Dolomite*).
Carbonate of Protoxide of Manganese (*Diallogite*).
Carbonate of Zinc (*Calamine*).
Carbonate of Iron (*Spathic Iron*).
Nitrate of Soda.
Hydrate of Magnesia (*Brucite*).

β. Trimetric[1] Crystals.

CHARACTERS.—*Geometric:* axes three, unequal. *Optical:* refraction double in all directions except two (two axes of double refraction). *Thermotic:* expansion unequal in three directions.

⁂ As the crystals of this subclass have two axes of double refraction, a double system of rings, intersected by bands, is seen when they are placed in the polariscope (see figs. 33 and 34).

---

[1] Trimetric, from τρὶς, *thrice*, and μέτρον, *a measure*—axes of three kinds.

FIG. 33.

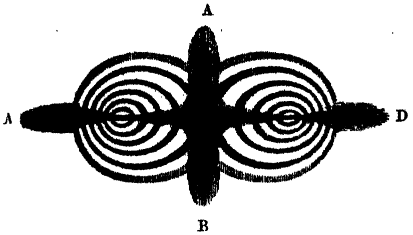
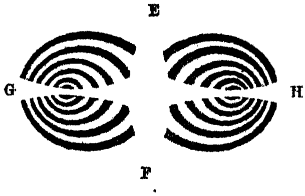


FIG. 34.



Double system of rings seen by looking through a slice of nitre (cut perpendicularly to the prismatic axis of the crystal), placed in the polariscope.

When the polariser and analyser are at right angles to each other, the cross is a black one (fig. 33, A, B, C, D); but when the position of the polariser and analyser coincide, the cross is a white one fig. 34, E, F, G, H).

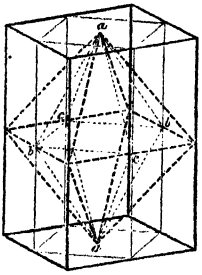
System 4.—Right Prismatic System.

(Prismatic System, *Miller*. The 1- and 1-axed System, *Rose*. The 2- and 2-membered System.)

CHARACTERS.—*Geometric:* axes three, rectangular, unequal. *Optical:* refraction double in all directions except two (two axes of double refraction). *Thermotic:* expansion relatively unequal in the directions of all the axes.

FORMS.—To this system belong the *octohedron with a rectangular base*, the *right rectangular prism*, the *octohedron with a rhombic base*, and the *right rhombic prism.*

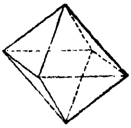
FIG. 35.



Four forms of the right prismatic system; viz. right rectangular prism, right rhombic prism, rectangular octohedron, and rhombic octohedron.

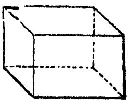
a a, Principal or prismatic axis; *b b*, *c c*, secondary axes.

FIG. 36.



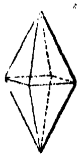
Octohedron with a rectangular base.

FIG. 37.



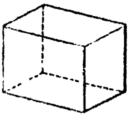
Right rectangular prism.

FIG. 38.



Octohedron with a rhombic base.

FIG. 39.



Right rhombic prism.

EXAMPLES.—The following substances belong to this system:—

Iodine.
Sulphur (native).
Selenium?
Binoxide of Manganese (*Pyrolusite*).
Teroxide of Antimony (*White Antimony*).
Chloride of Barium.
Bichloride of Mercury (*Corrosive Sublimate*).
Tersulphuret of Antimony (*Gray Antimony*).
Tersulphuret of Arsenicum (*Orpiment*).
Bisulphuret of Iron (*Radiated Pyrites*).
Arsenical Pyrites (*Mispickel*).
Sulphuret of Bismuth.
Bisulphate of Potash.
Sulphate of Potash[1].
Sulphate of Magnesia.
Sulphate of Zinc.
Sulphate of Baryta (*Heavy Spar*).

[*Continued.*

---

[1] The common bipyramidal crystals of sulphate of potash are composite crystals made up of several crystals belonging to the right prismatic system agglutinated so as to form bipyramidal dodecahedra, simulating the crystals of the rhombohedric system (Brewster).

Sulphate of Strontian (*Celestine*).
Sulphate of Lead (*Prismatic Lead Spar*).
Sulphate of Ammonia.
Perchlorate of Potash.
Nitrate of Silver.
Nitrate of Potash.
Carbonate of Potash.
Bicarbonate of Ammonia with 2½ HO.
Bicarbonate of Potash.
Carbonate of Lime (*Arragonite*).
Carbonate of Lead (*White-Lead Ore*).
Carbonate of Baryta (*Witherite*).
Carbonate of Strontian (*Strontianite*).
Ferridcyanide of Potassium.
Acetate of Baryta.
Acetate of Lead.
Bitartrate of Potash (*Cream of Tartar*).
Tartrate of Potash and Soda (*Rochelle Salt*).
Tartrate of Potash and Antimony (*Emetic Tartar*).
Citric Acid.
Morphia.
Codeia.
Narcotina.
Asparagine.

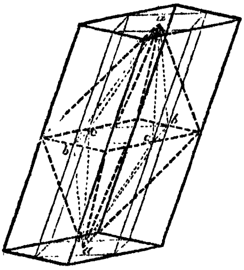
System 5.—Oblique Prismatic System.

(The 2- and 1-membered System, *Rose*.)

CHARACTERS.—*Geometric:* axes three, all unequal; two of them cut one another obliquely, and are perpendicular to the third. *Optical:* refraction double in all directions except two (two axes of double refraction). *Thermotic:* expansion in the direction of the axes relatively unequal.

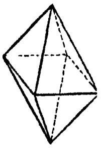
FORMS.—To this system belong the *oblique octohedron with a rectangular base*, the *oblique rectangular prism*, the *oblique octohedron with a rhombic base*, and the *oblique rhombic prism*. Mr. Brooke[1] refers the *right oblique-angled prism* to this group.

FIG. 40.



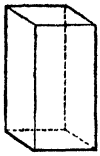
Four forms of the oblique prismatic system; viz. oblique rectangular prism, oblique rhombic prism, oblique rectangular octohedron, and oblique rhombic octohedron.
a a, Principal axis; *b b*, *c c*, secondary axes.

FIG. 41.



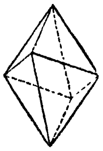
Oblique octohedron with a rectangular base.

FIG. 42.



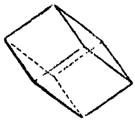
Oblique rectangular prism.

FIG. 43.



Oblique octohedron with a rhombic base.

FIG. 44.



Oblique rhombic prism.

The following substances belong to this system:—

Sulphur (by slow cooling).
Bisulphuret of Arsenicum (*Realgar*).
Oxysulphuret of Antimony (*Red Antimony*).
Sulphate of Soda.
Sulphate of Iron.
Sulphate of Lime (*Selenite*).
Chlorate of Potash.
Triphosphate of Soda and Basic Water (*Rhombic Phosphate*).
Borax (*Tincal*).
Carbonate of Soda.
Sesquicarbonate of Soda (*Trona*, *Urao*).
Acetate of Soda.
Acetate of Copper.
Acetate of Zinc.
Binacetate of Copper.
Binoxalate of Potash.
Cinnamic Acid.
Succinic Acid.
Tartaric Acid.
Oxalic Acid.
Sugar.
Crystals from Oil of Cubebs.

System 6.—Doubly-oblique Prismatic System.

(The 1- and 1-membered System, *Rose*.)

CHARACTERS.—*Geometric:* axes three, all unequal, and oblique-angular to one another. *Optical:* refraction double in all directions except two (two axes of double refraction). *Thermotic:* expansion in the direction of the axes relatively unequal.

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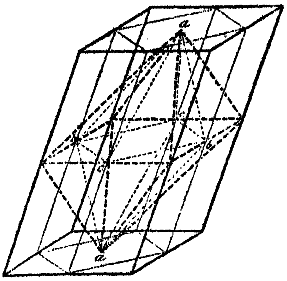
[1] *Encyclopædia Metropolitana*, art. *Crystallography*.

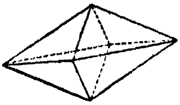
FORMS.—To this system belong the *doubly-oblique octohedron* and the *doubly-oblique prism.*

FIG. 45.



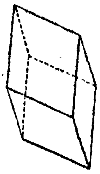
Four forms of the doubly-oblique system; viz. two doubly-oblique prisms, and two doubly-oblique octohedra. *a a*, Principal axis; *b b*, *c c*, secondary axes.

FIG. 46.



Doubly-oblique octohedron.

FIG. 47.



Doubly-oblique prism.

EXAMPLES.—The following substances belong to this system:—

Boracic Acid.
Paratartaric Acid (*Racemic Acid*).
Gallic Acid.
Sulphate of Protoxide of Manganese with 5 HO.
Sulphate of Copper (*Blue Vitriol*).
Sulphate of Cinchonia.
Nitrate of Bismuth.
Quadroxalate of Potash.
Succinate of Ammonia.

Isomorphism.—I have already (p. 81) had occasion to allude to the relation which Dr. Blake believes to exist between isomorphism and the physiological effects of crystalline substances.

εε. Artificial Method of Linnæus.

This appears to me the best place for noticing those pharmacological works in which the Linnæan artificial method of arranging plants is followed.

Car. A. Linné—Materia Medica, ed. 4a curante J. C. D. Schrebero. Lipsiæ et Erlangæ, 1782.
P. J. Bergius—Materia Medica e Regno vegetabili, 2 tom. ed. 2nda. Stockholmiæ, 1782.
P. L. Geiger—Handbuch der Pharmacie, 2 Bde. Heidelberg, 1829. [The second edition is arranged in natural-historical order.]
A. A. da Silveira Pinto—Pharmacographia do Codigo Pharmaceutico Lusitano. Coimbra, 1836.

ζζ. Methods founded on the Parts of Organized Beings employed.

In some works, the vegetable and animal substances employed in medicine are classified according to the parts used; as barks, roots, seeds, secretions, &c.

R. A. Vogel—Historia Materiæ Medicæ. Ludg. Batav. et Lipsiæ, 1758.
C. Alston, M.D.—Lectures on the Materia Medica, 2 vols. London, 1770.
J. C. Ebermaier, M.D.—Taschenbuch der Pharmacie. Leipzig, 1809.
N. J. B. G. Guibourt—Histoire abrégée des Drogues simples, 2de éd. Paris, 1826.—3me éd. 1836.
Dr. F. Goebel and *Dr. G. Kunze*—Pharmaceutische Waarenkunde. Eisenach, 1827-29.
Dr. T. W. C. Martius—Grundriss der Pharmakognosie des Pflanzenreiches. Erlangen, 1832.

γ. Classifications founded on the Chemical Constituents.

The difficulties attending the analysis of organised substances present a great obstacle to the formation of a chemical classification. Most of the writers who have attempted an arrangement of this kind are Germans.

Donald Monro—A Treatise on Medical and Pharmaceutical Chemistry, and the Materia Medica, 3 vols. London, 1788.
F. J. Voltelen—Pharmacologia universa, 8vo. Lugd. Bat. 1797-1802.

C. H. Pfaff—System der Materia Medica nach chemischen Principien mit Rücksicht auf. d. sinnl. Merkmale und d. Heilverhältnisse der Arzneimittel, 7 Bde. Leipzig, 1808-24.

F. A. C. Gren—Handbuch der Pharmacologie, 3te Aufl. herausgegeben von *Berhardi* und *Buckholz*, 2 Bde. Halle u. Berlin, 1813.

F. G. Voigtels—Vollständ. System der Arzneymittellehre, herausgegeben von *Kuhn*, 4 Bde. Leipzig, 1816-17.

C. W. Hufeland—Conspectus Materiæ Medicæ. Berolini, 1816.—Edit. 2. 1820.—Edit. 3. 1828.

G. W. Schwartze—Pharmacologische Tabellen, oder systematische Arzneimittellehre in tabellarischer Form. fol. Leipzig, 1819-25.—2 Aufl. 1833.

G. A. Richter—Ausführliche Arzneimittellehre. Handbuch für praktische Aerzte. 5 Bde. u. 1.—Suppl. 1826-32.

L. A. Kraus—Wissenschaftliche Uebersicht der gesammten Heilmittellehere. Götting. 1831.

J. F. Sobernheim—Handbuch der praktischen Arzneimittellehre, 4to. Berlin, 1841.—5te Ausg. Berlin, 1844.

As an example of a chemical classification, I shall select that of Schwartze, and must refer the reader to the late Dr. Duncan's (jun.) *Edinburgh Dispensatory*, 11th edit. p. 172, for Pfaff's chemical classification of the vegetable materia medica.

SCHWARTZE'S CLASSIFICATION.

Div.
1. Aqua communis.
2. Gummosa, mucilaginosa.
3. Farinosa, amylacea.
4. Gelatinosa.
5. Albuminosa.

Div.
6. Saccharina.
7. Pinguia-oleosa.
8. Extractiva amara.
9. Adstringentia seu Tannica.
10. Ætherea-oleosa.

Div.
11. Resinosa.
12. Narcotica.
13. Spirituosa
14. Acida.
15. Alcalina.
16. Salina.

Div.
17. Metallica.
18. Corpora simplicia, solida, non metallica.
19. Kalia sulphurata.
20. Sapones.

It will be observed that the author has not always founded his divisions on the chemical properties of medicines; since some of them refer partly or wholly to the effects produced by these agents on the body. The nomenclature is not always perfect: thus, his seventeenth class is called "Metallica," as if it alone contained metallic substances; whereas divisions fifteen and sixteen also contain them. Again, some of the divisions, for example "Resinosa," contain substances whose effects are most dissimilar; while substances of analogous operation are placed in separate divisions.

aa. Inorganic Substances.

The mineral and other inorganic substances of the Materia Medica are arranged chemically in the following works:—

J. F. Gmelin—Apparatus Medicaminum. P. II. Regnum Minerale complectens, 2 vols. 8vo. Goettingæ, 1795-6.

J. Stephenson, M.D.—Medical Zoology and Mineralogy. Lond. 1832. [See ante, p. 133.]

Geiger's Handbuch der Pharmacie—Pharmaceutische Mineralogie, von *P. L. Geiger*, 2te Aufl. neu bearbeitet von Dr. *Clamor Marquart*. 1838.

Cl. Marquart—Lehrbuch der praktischen und theoretischen Pharmacie. Pharmaceutische Mineralogie (in the first volume). Mainz, 1844.

M. A. Richard—Précis Elémentaire de Minéralogie, contenant des notions générales sur la Minéralogie, et la description de toutes les espèces employées dans les Arts et particulièrement la Médecine. Paris, 1835.

Dr. E. Ballard and *Dr. A. B. Garrod*—Elements of Materia Medica and Therapeutics. London, 1845. [See ante, p. 136.]

Dr. J. F. Royle—A Manual of Materia Medica and Therapeutics. London, 1847. [See ante, p. 136.]

The inorganic substances of the present work are arranged on chemical principles.

δ. Classifications founded on the Physiological Effects of Medicines.

As the ultimate object of all our inquiries into the Materia Medica is to obtain a knowledge of the mode of operation of medicinal substances, it follows, that the most desirable and useful, because the most practical, classification of these agents, would be that founded on the similarity of their effects. But so many difficulties exist in the way of producing such an arrangement—so much remains yet to be determined with respect to the nature of the modifications impressed on the organised tissues by the influence of medicines—that it must be evident to every one who attentively studies the subject, that in the present state of our knowledge, no such classification can be satisfactorily effected.

Physiological classifications are variously formed. Those that I am acquainted with may be reduced to six groups or classes. Thus, they may be arranged:—

1. According to the general quality of the effects.
2. According to Brunonian principles.
3. According to the doctrine of contra-stimulus.
4. According to the doctrine of Broussais.
5. According to chemico-physiological principles.
6. According to the part affected.

1. According to the General Quality of the Effects.

These arrangements are founded on the *nature, quality,* or *general character* of the effects; as in the following works:—

W. Cullen, M.D.—Treatise of the Materia Medica. Edinburgh, 1789.

R. Pearson, M.D.—A Practical Synopsis of the Materia Alimentaria and Materia Medica. London, 1808.

C. I. A. Schwilgué—Traité de Matière Médicale, 2 tom. Paris, 1818.

J. Arnemann—Chirurgische Arzneimittellehre, 6te Aufl. von *A. Kraus*. 1818.

J. Arnemann—Praktische Arzneimittellehre, 6te Aufl. von *L. A. Kraus*. 1819.

T. Young, M.D.—An Introduction to Medical Literature, art. Pharmacology, 2d edition. 1823.

J. B. G. Barbier—Traité Elémentaire de Matière Médicale, 2nde édit. 3 tom. Paris, 1824.—4e édit. 1837.

N. Chapman, M.D.—Elements of Therapeutics and Materia Medica, 4th edit. Philadelphia, 1825.

Dr. Nuttall—Lancet, vol. ix. p. 578.

H. M. Edwards and *P. Vavasseur*, M.D.—Manuel de Matière Médicale. Paris, 1826.—English Translation, by *Davis*. 1831.

C. Sundelin—Handbuch der speciellen Heilmittellehre, 2 Bde. 3te Aufl. 1833.

John Murray, M.D.—A System of Materia Medica and Pharmacy, 5th edit. Edinb. 1828.

A. Duncan, M.D.—Physiological Classification of the Materia Medica. In the Supplement to the New Dispensatory, 11th edit. 1829.

J. Wendt—Praktische Materia Medica. Breslau, 1830.—2te Aufl. 1833.

F. Foy—Cours de Pharmacologie, 2 tom. Paris, 1831.

A. T. Thomson, M.D.—Elements of Materia Medica and Therapeutics, 2 vols. 1832.—2d edit. in 1 vol. 1835.

E. S. and *K. D. Schroff*—Arzneimittellehre und Receptirkunde. Wien. 1833.

A. Trousseau et *H. Pidoux*—Traité de Thérapeutique, 1er tom. Paris, 1836; 2nd tom. 1re part. 1837; 2e part. 1839.—2e édit. 1841.

C. G. Mitscherlich—Lehrbuch der Arzneimittellehre, 1re Bd. 1837-1840; 2er Bd. 1846-1847, Berlin.

Carl Heinr. Schultz (Schultzenstein)—Natürliches System der allgemeinen Pharmakologie nach dem Wirkungsorganismus der Arzneien, 8vo. Berlin, 1846.
F. Oesterlen—Handbuch der Arzneimittellehre, 8vo. Tübingen, 1845.—2te Aufl. 1847.
Dr. J. M. Neligan—Medicines, their Uses and Mode of Administration, 8vo. Dublin, 1844.—2d edition, 1847.

As examples of this kind of classification, I subjoin those of Duncan, Sundelin, C. G. Mitscherlich, and Schultz.

DR. DUNCAN'S PHYSIOLOGICAL CLASSIFICATION OF THE MATERIA MEDICA.

External agents act—

I. By nourishing the body	ALIMENTA.	
(a) Drink	POTUS.	
When they act medicinally		DILUENTIA.
(b) Food	CIBI.	
When they act medicinally		DEMULCENTIA.
II. By evacuation	EVACUANTIA.	
(a) By the skin insensibly		DIAPHORETICA.
By the skin sensibly		SUDORIFICA.
(b) By the mucous membrane		
Of the nostrils		ERRHINA.
Of the lungs		EXPECTORANTIA.
Of the stomach		EMETICA.
Of the intestines		CATHARTICA.
Of the uterus		EMMENAGOGA.
(c) By glandular secretion		
The kidneys		DIURETICA.
The salivary glands		SIALOGOGA.
III. By exciting the vital powers	STIMULANTIA.	
(a) Chiefly of the parts to which they are applied.	TOPICA.	
Applied externally		
Causing redness		RUBEFACIENTIA.
Causing serous secretion		VESICANTIA.
Causing purulent secretion		SUPPURANTIA.
Administered internally		
CONDIMENTA when alimentary		
When acting medicinally		CARMINATIVA.
(b) Of the system generally	GENERALIA.	
(a) Obscurely, but more durably	PERMANENTIA.	
Producing no immediate obvious effect		TONICA.
Constricting fibres and coagulating fluids		ASTRINGENTIA.
(b) More evidently, but less durably	TRANSITORIA.	
Acting on the organic functions		CALEFACIENTIA.
Acting on the mental functions		INEBRIANTIA.
IV. By depressing the vital powers	DEPRIMENTIA.	
Acting on the organic functions		REFRIGERANTIA.
Acting on the mental functions		NARCOTICA.
V. By chemical influence on the fluids	CHEMICA.	
Acidifying		ACIDA.
Alkalizing		ALKALINA.

A very cursory examination of the substances placed by the author under each of the above classes will satisfy the most superficial observer, that this classification does not, in a large number of instances, effect that which it proposes to do; namely, to arrange together "substances according to the effects which they produce in a state of health." For example, under the head of diaphoretics and sudorifics we have mustard, copaiva, opium, ipecacuanha, alcohol, antimony, ammonia, and mercury; among narcotics are opium, nux vomica, foxglove, saffron, and colchicum; in the class sialogogues we have horseradish, tobacco, and mercury. Now, no one will pretend to affirm that the substances thus grouped together operate in an analogous manner on the system, or that their effects are similar.

SUNDELIN'S CLASSIFICATION.

A. AGENTS WHICH LESSEN VITALITY, AND ARE ADAPTED FOR AN ABNORMAL AUGMENTATION OF IT.	B. ALTERATIVE AGENTS ADAPTED FOR AN ALTERATION OF VITALITY.	C. AGENTS WHICH AUGMENT VITALITY, AND ARE ADAPTED FOR APPARENTLY OR ACTUALLY LESSENED VITALITY.
I. *Debilitating agents adapted for genuine hypersthenia.* a. Agents diminishing the blood and fluids. 1. Bloodletting. 2. Antiphlogistic purgatives. b. Debilitating agents in a limited sense—temperants. c. Agents which abstract heat.	I. *Resolvents adapted for an alteration of vitality from material causes.* a. Solvents. b. Absorbents. c. Liquefacients. d. Irritating resolvents. e. Strengthening resolvents. 1. Excitants. 2. Tonics.	I. *Irritants adapted for torpid debility.* a. Resolvents. b. Drastics. c. Acrids.
II. *Relaxants adapted for abnormal tension of fibres, and for augmented irritability and sensibility.* a. Oleaginous substances. b. Mucilaginous, amylaceous, and albuminous substances. c. Saccharine substances.	II. *Evacuants adapted for retentions.* a. Emetics. b. Purgatives. c. Emmenagogues. d. Diuretics. e. Diaphoretics. f. Diaphoretico-diuretics, or the so-called purifiers of the blood. g. Cutaneous irritants. h. Anthelmintics.	II. *Strengthening agents adapted for true debility.* a. Animating, analeptics. b. Exciting - animating agents. c. Exciting-strengthening agents. 1. Carminatives. 2. Aromatic herbs. 3. Powerful excitants. 4. Balsamics. 5. Irritating excitants. 6. Empyreumatic agents. 7. Spices. 8. Exciting irritants. d. Tonics. 1. Consolidating agents. 2. Tonic bitters. 3. Astringents. 4. Antiseptics. 5 Exciting tonics.
	III. *Alteratives adapted for altered sensibility and irritability.* a. Narcotics adapted for hyperæsthesis and convulsability. 1. Depressing narcotics. 2. Exciting narcotics. 3. Resolvent-acronarcotics. 4. Acronarcotics. 5. Bitter poisonous narcotics. 6. Metallic substances.	

In this classification, the author assumes that medicines act in one of three ways only, viz. by lessening, by altering, or by augmenting vitality (see *ante*, p. 95). There is, therefore, in this arrangement, no place for agents which act simultaneously in two of these three ways: for example, by both altering and augmenting vital action. This defect leads the author into many errors in the details of his classification; and it will be found that most of the agents placed in the third division (C) are, in reality, referable to the second division (B), on account of their alterative action.

DR. C. G. MITSCHERLICH'S CLASSIFICATION.

1st Class—Medicamenta tonica.

Order I. Amara.
II. Adstringentia.
III. Ferri præparata.
Appendix— Manganesii præparata.
IV. Frigus.

2d Class—Medicamenta emollientia et nutrientia.

Order I. Mucilaginosa.
II. Amylacea.
III. Pinguia et oleosa.
IV. Albuminosa et caseosa.
V. Gelatinosa.
VI. Saccharina.
VII. Calor humidus.

3d Class—Medicamenta excitantia.

Order I. Tonico-excitantia.
II. Excitants which promote digestion.
III. Excitants which promote the secretions and excretions.
IV. Excitants which affect the brain and spinal cord.
V. Calor siccus.
Appendix—Camphor, arnica, sulphur, carburet of sulphur, empyreumatic oils, electricity.

4th Class—Medicamenta acria.

Order I. Aromata acria.
II. Emetica acria.
III. Cathartica drastica seu acria.
IV. Diuretica acria.
V. Narcotico-acria.
[*Emmenagoga acria* are made a distinct order in the introduction; but in the subsequent division of the classes they are omitted.]

5th Class—Medicamenta temperantia.

Order I. Acida temperantia.
II. Acida tonica-temperantia.

6th Class—Medicamenta solventia.

Order I. Caustica alkalina.
II. Salia media.

7th Class—Medicamenta narcotica.

Order I. Agents which paralyse the activity of the whole nervous system (e. g. *acidum hydrocyanicum*).
II. Agents which especially act on the spinal marrow, and at first increase but soon interrupt sensation and motion (e. g. *nux vomica*).
III. Agents which especially interrupt the function of the brain, and also that of the spinal cord and sympathetic nerves (e. g. *hyoscyamus* and *belladonna*).
IV. Agents which at first change and at last stupefy the peculiar activity of the brain, interrupt the function of the spinal cord, and at the same time act as powerful alteratives on the sympathetic nerves (e. g. *opium*).
V. Narcotico-acria (e. g. *digitalis*).
Appendix—Medicamenta mentem deprimentia et alterantia (psychica).

8th Class—Medicamenta alterantia.

Order I. The earths and their compounds.
II. The metals and their compounds.

9th Class—Medicamenta incertæ sedis.

The first part of Dr. Mitscherlich's work, in which he gave an outline of his proposed classification, was published in 1837. Several other parts, embracing descriptions of the first, second, third, and fourth classes, have subsequently appeared; and in these he has somewhat modified the subdivisions of the first four classes. These modifications I have embodied in the above table. The five latter classes remain as they were produced in 1837.

Dr. C. H. Schultz's classification.—The most extraordinary modern classification is that of Dr. C. H. Schultz, of which the following is an outline:—

DR. C. H. SCHULTZ'S CLASSIFICATION.

A. BIOLYTICA. Their action tends to the dissolution of life and structure (*dissolventia organica*). They weaken and disorganize, and are opposed to organization and assimilation. *Venena.*	1. *Plastilytica.* For vegetative life. Metals, haloids.	1. *P. morpholytica.* Acting chiefly on the morbid vegetation of cells, bones, and glands.	The colliquescent metals: mercury, antimony.
		2. *P. haematica.* Acting chiefly on the blood and vessels.	The caustic irritating metals: copper, arsenic, silver, gold.
		3. *P. myotica.* Acting chiefly on the muscles and nerves.	The astringent metals: iron, lead, zinc, bismuth.
		4. *P. lymphatica.* Acting chiefly on the lymphatic system. They check both decomposition and assimilation.	Iodine, bromine, chlorine, carbon.
	2. *Erethilytica* (Haematolytica). Acids, salts, mucus.	1. *H. physoda.* Acting on the blood-corpuscles.	Mineral acids, vegetable acids.
		2. *H. plasmatoda.* Acting on the blood-plasma.	Alkaline and earthy salts, mucus.
	3. *Neurolytica.*	1. *Phrenolytica.* Acting chiefly on the brain.	Prussic acid, stramonium, hyoscyamus, belladonna, dulcamara, nicotiana, amanita muscaria.
		2. *Aesthesilytica.* Senses-narcotics (paralyzing feeling and allaying pain).	Aconitum, pulsatilla, helleborus niger, clematis, primulaceæ, secale cornutum.
		3. *Myelolytica.* Excitoparalytica.	Conium, cicuta, phellandrium, digitalis, and other scrophularineæ.
B. ANABIOTICA. Their action tends to the increase of vitality, of organization, and of animation. They therefore preserve (*continentia*), organize, and strengthen.	4. *Plastibiotica.*	1. *P. anapeptica.* Influencing assimilation.	Amara.
		2. *P. anatrophica* …………	Gelatinosa, albuminosa, oleosa, farinosa.
		3. *P. myotica* (anerethica). Action chiefly on the irritable organs.	Adstringentia vegetabilia.
	5. *Erethibiotica* (Haematobiotica). Aethereo-oleosa.	1. *E. anapeptica* (homoeotica). Action chiefly on the digestive organs and sanguification.	Volatile oil, combined with bitter and astringent substances, aromatica, cinnamon, cloves, ginger, &c.
		2. *E. pneumatoda* (physoda). Action chiefly on the blood-corpuscles, the lungs, and heart.	The mint-like volatile oils of labiatæ, the valerianæ, many compositæ.
		3. *E. neuroda.* Action through the blood on the nerves.	Volatile oil in combination with resin, bals. peruvianum, b. copaivæ, myrrha, olibanum, benzoin, gum-resins of umbelliferæ.
	6. *Neurobiotica.*	1. *Phrenobiotica.*	Opium, cannabis, humulus, ether, alcohol, wine.
		2. *Myelobiotica.* Excitocontractoria.	Strychneæ, nux vomica, ignatia. Menispermeæ, cocculus, columbo: coriaria myrtifolia.
		3. *Aesthesibiotica.*	Moschus, castoreum, ammoniacalia, empyreumatica.
C. AGONISTICA. Their action tends to the production of a defensive process, as in diseases. They excite artificial fever, inflammations, and vomitings, with attempts at expulsion. *Vis expellens, drastica* opposed to *vis continens.* (*Apolytica.*)	7. *Plastagonistica.*	1. *P. enteragoga.* Laxantia, sialagoga (stomatagoga), cholagoga.	Senna, tamarinds, manna, geoffroya, jalapa.
		2. *P. dermatagoga.* Sudorifics.	Sambucus, jacea, ammoniacal salts.
		3. *P. nephragoga.* Diuretics.	Alkalia, sapones, saponaria, sarza, carex arenaria.
	8. *Erethagonistica.* Acria.	1. *E. phlogoga.* Rubefacientia, urentia, suppurantia.	Euphorbiaceæ, thymeleæ (mezereon), meloes majales, cantharides, phosphorus, veratrineæ (veratrum album, colchicum), cruciferæ (sinapis cochlearia), piperineæ (cubebæ).
		2. *E. haematagoga.*	Toxicodendron, asarum, aristolochia, taxus, sabina, juniperus, crocus, aloë, allium, sulphur.
	9. *Neuragonistica.* (Neuropolytica).	1. *Pneumonapolytica.* (Expectorantia, errhina).	Senega, arnica, pyrethrum acmella, scilla, arum, r. ireos.
		2. *Enteropolytica.* Gastrapolytica (emetica), colicapolytica (tenesmica, eccoprotica).	Ipecacuanha, cainana, cucurbitaceæ (elaterium bryonia, colocynthis), guttiferæ.

2. According to Brunonian Principles.

Some physicians have classified the articles of the Materia Medica in accordance with *Brunonian principles*. I have before (see p. 96) stated that Brown regarded all medicines as stimulants; that is, as agents causing excitement. But he supposed some of them to produce less excitement than is requisite for health; and, therefore, to be the remedies for sthenic diathesis: hence they were termed *debilitating* or *antisthenic*. On the other hand, some agents give more excitement than suits the healthy state; and are, therefore, the remedies for the asthenic diathesis. These he called *stimulant* or *sthenic*[1]. The following pharmacological works are based on Brunonian principles[2]:—

Versuch einer einfachen praktischen Arzneimittellehre. Wien, 1797.

Pharmacopœia Browniana, oder Handbuch der einfachsten und wirksamsten Heilmittel, mit klinischen Bemerkungen im Geiste der geläuterten neuen Arzneilehre. Stuttgart, 1798.

J. S. Frank—Versuch einer theoretisch-praktischen Arzneimittellehre nach den Grundsätzen der Erregungstheorie. Erlangen, 1802.—2 Aufl. Wien, 1804.

C. F. Oberreich—Umriss einer Arzneimittellehre nach den Grundsätzen der Erregungstheorie. Leipzig, 1803.

J. J. Chortet—Traité de Pharmacologie, basée sur la théorie de Brown. Paris, 1806.

F. Wurzer—Grundriss der Arzneimittellehre. Leipzig, 1808.

J. H. Müller—Handbuch der Lebens-und Arzneimittellehre. Leipzig, 1809.

J. A. Neurohr—Versuch einer einfachen praktischen Arzneimittellehre. Zweite Aufl. Heidelberg, 1811.

K. Schöne—Praktische Arzneimittellehre für Aerzte unde Wundärzte nach den Grundsätzen der Erregungstheorie. 2 Bde. Berlin, 1815.

3. According to the Doctrine of Contra-Stimulus.

In the following work, the articles of the Materia Medica are arranged according to the doctrine of contra-stimulus:—

G. Giacomini—Trattato filosofico-sperimentale dei soccorsi terapeutici. 4 vols. 8vo. Padova, 1833-36.

GIACOMINI'S CLASSIFICATION.

Class I. *Hypersthenics.*

Order 1. *Cardiaco-vasculo-hypersthenics*: ammonia and its carbonate.
Order 2. *Vasculo-cardiac hypersthenics*: the ethers.
Order 3. *Cephalic hypersthenics*: opium, morphia, and narcotina.
Order 4. *Spinal hypersthenics*: alcohol, rum, cherry-spirit, and wine.
Order 5. *Gastro-enteric hypersthenics*: volatile oils, cinnamon, cloves, and nutmegs.

Class II. *Hyposthenics or Contra-stimulants.*

Order 1. *Cardiaco-vasculo-hyposthenics*: hydrocyanic acid, laurel water, bitter almonds, peach leaves and flowers, black cherries, cantharides, digitalis, squills, colchicum, white hellebore, cebadilla, camphor, peppermint, sage, chamomile, venice turpentine, balsam of copaiva, juniper, carbonic acid, nitre, acetate of potash, and asparagus.
Order 2. *Vasculo-cardiac hyposthenics*:
  Sect. 1. *Arterial vasculo-hyposthenics*: antimonials, aconite, ipecacuanha, elder flowers, dulcamara, sarsaparilla, guaiacum, sulphur, sulphuret of potash, sulphuretted mineral waters, ergot of rye, cinchona, willow bark, iceland moss, and iron.
  Sect. 2. *Venous vasculo-hyposthenics*: sulphuric, nitric, hydrochloric, and nitro-

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[1] *The Works of Dr. John Brown*, vol. ii. p. 205, 1804.

[2] *Encyclopadisches Worterbuch der medicinischen Wissenschaften*, 3 Bd. art. *Arzneimittellehre.*

muriatic acids, chlorine, oxalic, citric, acetic, and boracic acids, mustard, and scurvy-grass.
Order 3. *Lymphatico-glandulo-hyposthenics:* mercurials, iodine, burnt sponge, bromine, chloride of barium, and hemlock.
Order 4. *Gastric hyposthenics:* bismuth, quassia, calumba, wormwood, wormseed, gentian, taraxacum, and bitters.
Order 5. *Enteritic hyposthenics:* tamarinds, cassia, prunes, manna, fixed oils of almonds, olives, linseed, and castor, cream of tartar, sulphates of magnesia, potash, and soda, carbonate of magnesia, senna, rhubarb, jalap, aloes, scammony, purgative elixir, gamboge, and the oils of caper spurge, and croton.
Order 6. *Cephalic hyposthenics:* belladonna, stramonium, henbane, and tobacco.
Order 7. *Spinal hyposthenics:* strychnia, nux vomica, St. Ignatius's bean, toxicodendron, lead, arnica, assafœtida, and valerian.

Andral[1], who quotes Fanzago, Tommasini, and Gozzi, says, that the Italians divide medicines into two classes, *dynamics* and *irritants*. The first comprehends those agents which augment or depress excitability,—stimulants and contra-stimulants; the second includes mechanical and chemical agents.

4. According to the Doctrine of Broussais.

The followers of Broussais, the founder of what the French denominate the *New Medical Doctrine*, or *Physiological Medicine*, consider all medicines to be either stimulants or debilitants. When a stimulant is applied to the affected organ, it is termed a direct stimulant; but when applied to a part more or less distant from that affected, it is termed a revulsive, or sometimes an indirect debilitant. Hence medicines are divided into *debilitants*, *direct stimulants*, and *revulsives*. This is the plan adopted in the following work:—

L. J. Begin—Traité de Thérapeutique, rédigé d'après les principes de la nouvelle Doctrine Médicale, t. ii. Paris, 1825.

5. According to Chemico-Physiological Principles.

Another mode of classifying medicines is on *chemico-physiological principles*; or, to use the phrase of Dr. Osann[2], "on the chemico-therapeutical basis of natural philosophy." This method has been adopted in the following works:—

K. F. Burdach—System der Arzneimittellehre, 1807-9. 3 Bde.—2te Aufl. 1817-19.

C. H. C. Bischoff—Die Lehre von den chemischen Heilmitteln, oder Handbuch der Arzneimittellehre. 3 Bde. Bonn, 1825-31.—[I have given a sketch of this classification in the *London Medical Gazette*, vol. xvii. p. 164.]

W. Grabau, M.D. Chemisch-physiologisches System der Pharmakodynamik. 1er Theil: Kiel, 1837. 2er Theil: Kiel, 1838.

6. According to the Part affected.

Another mode of classifying medicines is to arrange them according to the *particular structure or organ which they affect*; as into medicines acting specifically on the nervous system; medicines acting specifically on the vascular system, and so on. Some authors have formed their principal divisions, or classes of medicines, from the parts acted on; and their orders, from the nature or quality of the effect.

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[1] *Dict. de Méd. et de Chirurg. pratiq.* art. *Contre-Stimulant.*
[2] *Encyclop. Wörterb. d. med. Wissenschaften.*

The following writers have followed this order of classification:—

J. L. Alibert—Nouveaux Elémens de Thérapeutique et de Matière Médicale, 5me éd. 3 t. Paris, 1826.—[I have given a sketch of this classification in the *London Medical Gazette*, vol. xvii. p. 165.]

Dr. Granville—Medical and Physical Journal, for April 1822, vol. xlvii.

J. Eberle, M.D.—A Treatise on Materia Medica and Therapeutics, 2d ed. Philadelphia, 1824;—3d edit. 1825.

Ph. F. W. Vogt—Lehrbuch der Pharmakodynamik. 2 Bde. 2te Aufl. 1828;—3te Aufl. 1832.—4. Ausg. Giessen, 1843.

Dr. Michaelis—Encyclopädisches Wörterbuch de medicinischen Wissenschaften. Art. Arzneimittel. Berlin, 1829.

EBERLE'S CLASSIFICATION.

A.—Medicines that act specifically on the intestinal canal, or upon morbific matter lodged in it	I. Medicines that excite discharges from the alimentary canal		Emetics. Cathartics.
	II. Medicines calculated to destroy or counteract the influence of morbific substances lodged in the alimentary canal		Anthelmintics. Antacids.
B.—Medicines whose action is principally directed to the muscular system	I. Medicines calculated to correct certain morbid conditions of the system, by acting on the tonicity of the muscular fibre		Tonics.
	II. Medicines calculated to correct certain morbid states of the system, by acting on the contractility of the muscular fibre		Astringents.
C.—Medicines that act specifically on the uterine system	I. Medicines calculated to promote the menstrual discharge		Emmenagogues.
	II. Medicines calculated to increase the parturient efforts of the womb		Abortiva.
D.—Medicines that act specifically on the nervous system	I. Medicines that lessen the sensibility and irritability of the nervous system		Narcotics.
	II. Medicines that increase and equalise the nervous energy		Antispasmodics.
E.—Medicines whose action is principally manifested in the circulatory system	I. Medicines that increase the action of the heart and arteries		Stimulants.
F.—Medicines acting specifically upon the organs of secretion	I. Medicines that act on the cutaneous exhalents…	general	Diaphoretics.
		topical	Epispastics. Errhines. Emollients.
	II. Medicines that increase the action of the urinary organs		Diuretics.
	III. Medicines that alter the state of the urinary secretion		Antilithics.
	IV. Medicines that promote the secretory action of the salivary glands		Sialagogues.
G.—Medicines that act specifically upon the respiratory organs	I. Medicines calculated to increase the mucous secretion in the bronchia, and to promote its discharge		Expectorants. Inhalations.
	II. Medicines whose action is truly topical…		Emollients. Escharotics.

VOGT'S CLASSIFICATION.

Vogt makes three classes of medicines: the first including those agents which specially affect the *sensibility* of the body, the second containing those which alter the *irritability* of the system, and the third embracing those agents which influence what he calls the *vegetation* of the body—that is, the organic functions; namely, nutrition and reproduction.

	ORDERS.	DIVISIONS.
CLASS I. *Medicines operating specially on the nervous system, and particularly used as nervous agents*	1. Medicines which limit the vital manifestation of the nervous system (*narcotica*)	1. Opium and its allies. 2. Nux vomica, and medicines similar to it. 3. Hydrocyanic acid, and vegetables allied to it. 4. Belladonna, and medicines similar to it.
	2. Medicines which exalt and strengthen the vital manifestations of the nervous system (*nervina*)	1. Nervina volatilia (ammonia, musk, &c.) 2. Nervino-alterantia; antispasmodica (ipecacuanha, copper, zinc, bismuth, &c.)
CLASS II. *Medicines operating specially on irritable life.*	1. Weakening (*antiphlogistica*)	as the neutral salts, cold, &c.
	2. Medicines which heighten and strengthen the vital manifestations of the irritable system	1. Excitantia volatilia (as camphor, mints, &c.) 2. Tonica. 3. Antiseptica (acids, chlorine, &c.)
CLASS III. *Medicines operating specially on the vegetative* [organic] *system, and which are particularly used in diseases of vegetation* [nutrition and reproduction]	1. Medicines operating specially on the secreting and excreting systems...	1. Heat. 2. Gummi-resinosa, balsamica, and resinosa. 3. Resolventia (acrids, mercury, antimony, sulphur, alkalies, iodine, &c.)
	2. Medicines which specially operate on the formative process	1. Aromata (pepper, pyrethrum, nutmegs, &c.) 2. Nutrientia.

ε. Classifications founded on Therapeutical Properties.

The curative and remedial powers of medicines are not absolute and constant, but relative and conditional; so that we have no substance which, under every circumstance, is a remedy for a particular disease. This will explain why no modern author has attempted to classify remedies according to their therapeutical properties. Such a classification, if attempted, must be an arrangement of diseases, and an enumeration of the medicines which experience had found frequently, though not invariably, beneficial for each. On this principle, an *Index of Diseases and of Remedies according to the opinions of the ancient Greeks, Latins, and Arabs*, has been given in the following work:—

J. Rutty, M.D.—Materia Medica antiqua et nova, repurgata et illustrata, 4to. Rotterodami, 1775.

Strictly speaking, therefore, there are no substances to which the term *specifics* (*specifica qualitativa*, Hufeland[1]) can be properly applied. Yet it cannot be denied that there are many medicines which are particularly appropriated to the cure of certain diseases, or to the relief of particular symptoms; experience having shown that they more frequently give relief than other agents. As examples I may refer to the use of mercury in syphilis, disulphate of quina in ague, arsenious acid in lepra, and hydrocyanic acid in vomiting and gastrodynia. Moreover, I cannot admit that any satisfactory explanation has yet been given of the *modus medendi* of many of these agents. The relief obtained in constipation by the use of senna, and in pain by that of opium, is explicable by reference to the known physiological effects of these substances. But the benefit procured in venereal diseases by mercury, in ague by disulphate of quina, &c. cannot be accounted for by reference to any known physiological effects which these substances produce, and our use of them, therefore, is at present empirical. It cannot, however, be doubted that had we a more intimate acquaintance with, and precise knowledge of, the action of remedies, the therapeutical properties of medicines would no longer appear incomprehensible and mysterious.

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[1] *Lehrbuch der allgemeinen Heilkunde*, S. 194, 2te Aufl. Jena, 1830.

Though no systematic therapeutical classification has, to my knowledge, been attempted by modern authors, yet in some recent works several therapeutical classes have been admitted; especially in the following:—

F. Foy, M.D.—Cours de Pharmacologie, 2 tomes. Paris, 1831.—[His class of specifics includes antisyphilitics, antipsorics, febrifuges or antiperiodics, antiscrofulous medicines, and anthelmintics].

J. H. Dierbach, M.D.—Die neuesten Entdeckungen in der Materia Medica, 2te Ausg. 1er Band. Heidelberg und Leipzig, 1837.

7. PHYSIOLOGICAL CLASSES OF MEDICINES.

I have already (p. 145) expressed my opinion that, in the present state of our knowledge, a physiological classification of medicines cannot be satisfactorily effected. It is principally on this ground that I have thought it advisable, in the following pages, not to follow this kind of arrangement; though it appears to me advisable to precede the account of medicines individually, by some notice of the more important groups which they form when arranged on physiological principles.

In doing this, I shall adopt the following arrangement:—

	MEDICAMENTA.
1. Medicines employed for their external or topical effects.	*Topica.*
α. Acting mechanically	Class 1, T. Mechanica.
β. Acting chemically	Class 2, T. Chemica.
γ. Acting dynamically	Class 3, T. Dynamica.
2. Medicines employed for their remote or general effects.	*Generalia*[1].
α. Acting on the blood	Class 4, Hæmatica.
β. Acting on the respiratory organs	Class 5, Pneumatica.
γ. Acting on the nervous system	Class 6, Neurotica.
δ. Acting on the digestive organs	Class 7, Cœliaca.
ε. Acting on the excernent system	Class 8, Eccritica.
ζ. Acting on the sexual organs	Class 9, Genetica.

Class I. *Topica Mechanica.* Topical Medicines acting Mechanically.

These are topical remedies which operate therapeutically by a physical or mechanical agency.

This class includes mechanical antidotes, some purgatives and anthelmintics, and dentifrices.

ORDER 1. MECHANICAL ANTIDOTES.—In poisoning by caustic or acrid substances, considerable relief is generally obtained by the use of diluents, oily, mucilaginous, and other demulcent liquids, and fine impalpable powders. These substances lessen the injurious action of poisons by diluting and enveloping them, by sheathing the mucous surface of the stomach and intestines, and by obstructing absorption. Hence I have termed them mechanical antidotes.

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[1] The names given to the classes of the *generalia* are those used by Dr. Good, in his *Physiological System of Nosology*, to designate classes of disease.

Demulcentia.

Aqua.
Mucilaginosa.
Farinosa.
Saccharina.

Gelatinosa.
Albuminosa.
Oleosa.

Pulveres.

Carbo animalis.
Carbo ligni.
Farina.

Ferri sesquioxydum
Magnesia.

Some of these agents act, in particular cases, as chemical antidotes also, (see Class II. CHEMICA).

ORDER 2. PURGATIVES AND ANTHELMINTICS ACTING MECHANICALLY.—Some few medicinal agents, occasionally used as purgatives and anthelmintics, are employed on account of their mechanical influence. Three only require to be mentioned.

Hydrargyrum.
Stanni pulvis.
Mucuna pruriens—*Setæ.*

Metallic mercury is employed as a cathartic in alvine obstructions; while powdered tin and the hairs of the pods of cowhage are used as vermifuges. The first acts by its gravity; while the third, and perhaps the second also, operate as mechanical irritants.

ORDER 3. DENTIFRICES (*dentifricia* ; *ὀδοντόσμηγμα*; *ὀδοντότριμμα*) are mechanical agents, usually powders, employed for cleansing the teeth. They were in use among the Greeks and Romans[1]. The following substances form the bases of most of the dentifrices now in use:—

Pumex.
Bolus armeniaca[2].
Creta.

Os sepiæ.
Sodii chloridum.
Potassæ bitartras.

Myrrha.
Cinchonæ cortex.
Iridis florentinæ radix.

Sanguis draconis.
Catechu.

Tooth powders require to have a certain degree of hardness or grittiness to enable them to remove the foreign matters adherent to the teeth, but, if too hard, they are injurious to the enamel. Pumice powder is too gritty for frequent use. Employed occasionally (say once in two or three months) it is serviceable. Charcoal and cuttlefish bone powder are good detergents. Chalk is very soft. Ratanhy, cinchona, and catechu, are useful astringents. Myrrh is employed partly for its odour. All insoluble powders, however, are more or less objectionable, since they are apt to accumulate in the space formed by the fold of the gum and the neck of the tooth, and thus present a coloured circle. To hide this many tooth powders are coloured red with bole armeniac. The soluble substances which may be used as tooth powders are,—sulphate of potash, phosphate of soda, bitartrate of potash, and common salt.

Disinfecting and decolorizing tooth powders, washes, and lozenges, owe their efficacy to chloride of lime, and are used to destroy the unpleasant odour of the breath, and restore the white colour of the teeth when stained by tobacco[3], &c. Thus, one part of chloride of lime may be added to twenty or thirty parts of chalk, and used as a decolorizing tooth powder. A disinfecting mouth-wash is prepared by digesting three drachms of chloride of lime in two ounces of distilled water; and, to the filtered solution, adding two ounces of spirit, to which some scent (as otto of roses) has been added.

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[1] Galen, *De Compos. Medicam. secundum locos*, lib. v.; also, *Paulus Ægineta*, translated by Mr. Adams, vol. i. p. 455, et seq. Syd. Soc. 1844.

[2] The substance sold in the shops under this name is an artificial mixture of pipe-clay and sesquioxide of iron.

[3] *Journal de Chimie Médicale*, t. iii. p. 494; and t. iv. p. 28.

Class II. *Topica Chemica.* Topical Medicines acting Chemically.

This class includes those chemical agents which are employed in medicine as topical medicines.

We may divide them, according to the purposes for which they are used, into four orders; viz. *caustics*, *astringents*, *antidotes*, and *disinfectants*.

HAIR DYES (*tincturæ capillorum; βαφαὶ τριχῶν; βάμματα τριχῶν*) are chemical agents; but they are not included in this class, because their employment usually devolves on the hair-dresser. Yet, occasionally, a knowledge of them is useful to the medical practitioner. "Galen, when about to treat of compositions for the hair, remarks that the application of these does not belong properly to the physician; but that he may sometimes be obliged to furnish them to *royal ladies*, whom, under certain circumstances, he cannot venture to disobey[1]."

Hair dyes were in use by the ladies of antiquity[2]; and numerous recipes for their preparation are to be found in ancient medical authors[3].

Various substances,—some mineral, others vegetable,—have been used as hair dyes. The base of most of the powders, pastes, and liquids sold in the shops is either lead or silver. A mixture of finely-powdered litharge or carbonate of lead, and about an equal weight of slaked lime (to which starch is sometimes added) is frequently used[4]. It is made into a paste with water or skim milk, and applied with a brush. An oil-skin cap is then put on to prevent evaporation, and in four or five hours is removed, and the dye washed out. The water causes the oxide of lead to unite with the lime, forming a plumbite of lime. The lime is useful by removing the grease of the hair, while the lead combines with the sulphur contained in the hair, and forms the black sulphuret of lead. Leaden combs act on the same principle. Nitrate of silver is also extensively used as a hair dye. Hair, impregnated with a solution of this salt, blackens partly by the reduction of the silver, partly by the formation of the black sulphuret of silver. Sometimes a solution of hydrosulphuret of ammonia, to which caustic potash has been added, is applied to the air previous to the use of the nitrate. Other formulæ for hair dyes have been published[5]. The objections to the use of mineral hair dyes are, that they commonly communicate a reddish or purplish tint, and render the hair dry, crisp, and brittle.

Various vegetable substances have been employed; as the green shells of walnuts (*cortex nucum juglandis viridis*). These are used in the form of decoction, or of the so-called walnut liquor. The "Tinctur zum Schwarzfärben der Haare" is an alcoholic tincture of these shells scented with oil of lavender[6]. Pyro-gallic acid has recently been proposed as a hair dye[7].

The detection of stained hair is sometimes an object of medico-legal research[8]. Lead may be recognised in hair by boiling the latter in nitric acid, and applying the tests for lead to the nitric solution. To detect silver, the hair must be treated with chlorine, to form chloride of silver, which is soluble in ammonia. From the ammoniacal solution the chloride may be precipitated by nitric acid, and its nature ascertained by the usual means.

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[1] *Paulus Ægineta*, translated by Mr. Adams for the Sydenham Society, vol. i. pp. 342-4, 1844.—See also Galen, *De Compos. Medicam. secundum locos*, lib. i.

[2] Medea is said to have been acquainted with the art of dyeing grey hairs black, and partly in consequence of this she had the reputation of being able to restore youth to old people.

[3] *Galen*, supra cit.; *Paulus*, supra cit.; and *Alexander Trallianus*, i. 3.

[4] The use of a composition of this kind, called *Poudre d'Italie*, is said to have produced ophthalmia. (*Lond. Med. Gaz.* Nov. 18, 1842.)

[5] See Gray's *Supplement to the Pharmacopœia*, by Mr. Redwood, p. 740, Lond. 1847. Also, *Journal de Chimie Médicale*, tom. ii. p. 250, 2nde sér.

[6] Phœbus, *Handbuch der Arzneiverordnungs-lehre*, Th. ii. p. 148, 3tte Ausgabe, 1840.

[7] *Pharmaceutical Journal*, vol. iii. p. 585.

[8] Devergie, *Médecine Légale*, t. ii. p. 931, Paris, 1836; and Dr. Cummin, *Lond. Med. Gaz.* vol. xix. p. 215.

ORDER 1. CAUSTICA. *Cauteria potentialia.*—Chemical agents which destroy animal tissues and decompose interposed animal fluids are called *caustics* (from *καίω, I burn*). The chemical changes which the tissues and these agents respectively suffer, when they come in contact, have been before adverted to, (see pp. 89, 93-5). Remote or constitutional effects sometimes arise from the employment of caustics: they are in general produced by nervous agency, (see pp. 113, 114); but, in the case of the mercurial and arsenical preparations, they may be the result of absorption.

Caustics are conveniently grouped in two sub-orders—escharotica and cathæretica.

Sub-order 1. *Escharotica.*—The stronger caustics, which effect the complete destruction of the parts to which they are applied, and which give rise to the formation of an eschar, are called *escharotics* (from *ἐσχάρα*, an eschar,) or *corrosives*. They destroy both the structure and life of a part (morpholysis and biolysis. See p. 95). The eschar is succeeded by inflammation and suppuration in subjacent tissues, by which the slough is separated from the living parts.

The escharotics in most frequent use are—

Acidum sulphuricum.
Acidum nitricum.
Potassa.
Antimonii terchloridum.
Zinci chloridum.

They are employed—

1. To effect the destruction of living parts: thus to remove excrescences or morbid growths of various kinds,—such as warts, condylomata, some kinds of polypi, malignant growths, and spongy granulations; to form issues; and to open abscesses.

2. To decompose the virus of rabid animals, and the venom of the viper and other poisonous serpents.

Sub-order 2. *Cathæretica.*—The milder caustics, which enter into chemical combination with the tissues and decompose the animal fluids, are called *cathæretics* (from *καθαιρέω, I destroy*). They do not effect that complete destruction of parts which the escharotics do. Those in most frequent use are as follows:—

Iodinium.
Calx viva.
Liquor ammoniæ.
Arsenici tersulphuretum.
Acidum arseniosum.
Hydrargyri binoxydum.
Hydrargyri bichloridum.
Argenti nitras.
Cupri sulphas.
Cupri subacetas.
Zinci sulphas.
Zinci acetas.
Plumbi oxydum.
Plumbi acetas.
Alum.
Acidum aceticum.
Creasoton.

Cathæretics, besides entering into chemical combination with the tissues to which they are applied, frequently alter the living actions going on in subjacent parts. They are used for various purposes, of which the following are the principal:—

1. To effect the destruction or removal of parts,—as warts, hairs, &c.

EPILATORIES or DEPILATORIES (*depilatoria; psilothra*, *ψίλωθρα*, from *ψιλόω*, *I make bald,*) or medicines for removing hair from the skin, were in use among the ancients[1].

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[1] Galen, *De Compos. Medicam. secundum locos*, lib. i.; *Paulus Ægineta*, translated by Mr. Adams, vol. i. pp. 342 and 588.

They were frequently employed for immodest purposes. In modern times they have been used as cosmetics to remove superfluous hairs from the face, and as medicines to remove the hair from the scalp in the treatment of porrigo favosa. Lime or orpiment (tersulphuret of arsenicum) are the constituents of most of the ancient depilatories as well as of the modern ones sold by perfumers as cosmetics, including the Turkish *rusma*. But the use of orpiment is dangerous, especially when the skin is abraded. The best and safest depilatory for cosmetic purposes is said[1] to be "a strong solution of sulphuret of barium, made into a paste with powdered starch." It should be applied to the hair immediately after it is mixed, and allowed to remain there for five or ten minutes.

The alkalies are generally used for removing the hair in the treatment of porrigo favosa. Cazenave's *pommade épilatoire*[2] (an obvious imitation of the secret preparation of Messrs. Mahon) is as follows:—Carbonate of soda, 10 parts; lime, 5 parts; and lard, 40 parts. Mix.

2. To alter the action of subjacent parts. Most cathæretics are practically useful in this way: they effect a chemical change in the superficial parts, and alter the morbid action in subjacent ones. The employment of arsenious acid in lupus; of sulphate of copper and nitrate of silver in promoting the cicatrization of ulcers; of solutions of several metallic salts in inflammatory and other affections of the mucous membranes, (as in mucous and purulent ophthalmia, gonorrhœa, &c.); of tincture of iodine applied to the skin over joints affected with rheumatic or gouty inflammation; and of nitrate of silver in erysipelas—are examples of this use of cathæretics.

3. To stop hemorrhage from numerous small vessels. Cathæretics act as styptics, in part by causing contraction of the vessels, but principally by coagulating the blood.

ORDER 2. ASTRINGENTIA.—These are chemical agents which constrict fibres and coagulate albuminous fluids. When employed to obviate relaxation of fibres and tissues, and to check excessive secretion, they are called *astringents*; but, when used to repress hemorrhage, they are termed *styptics* (*styptica*). Those astringents which are employed to check secretion and exhalation, and which exercise but little corrugating power over the solids, are denominated *dessiccants* (*desiccantia*).

The following is a list of the most frequently employed astringents:—

Zinci oxydum.
Zinci carbonas.
Zinci sulphas.
Zinci acetas.

Plumbi acetas.
Plumbi subacetas.
Ferri sulphas.
Ferri sesquichloridum.

Cupri sulphas.
Hydrargyri bichloridum.
Argenti nitras.
Alum.

Calx.
Acidum tannicum.
Vegetabilia tannica[3].
Alcohol.

The astringents are, in fact, cathæretics acting in a milder and more dilute form. All of them react chemically on the animal solids and fluids. The chemical changes which take place have been already noticed, (see pp. 89 and 93). Astringents are not mere chemical agents: they operate dynamically also, and are powerful topical stimulants or excitants. But this dynamical influence, on which their utility as medicinal agents depends, is apparently a consequence of their chemical action, (see pp. 90 and 95).

The general indications for the use of the astringents are atony and relaxation of the solid parts, with profuse secretion. The general contra-indications for their use are, rigidity and hardness of the solids, great irritation or inflammation, and dryness of secreting surfaces.

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[1] Gray's *Supplement*, by Redwood, p. 737, 1847.

[2] Bourchardat, *Nouveau Formulaire Magistral*, p. 354, 3me édit. 1845.

[3] A list of the vegetable astringents containing tannic acid will be given hereafter (see *Tonics*).

As topical remedies, they are employed for the following purposes:—

1. To stop preternatural secretion from mucous surfaces; as in leucorrhœa, gonorrhœa, and gleet.
2. To check profuse secretion from ulcerated surfaces.
3. To stop hemorrhage; as from the uterus and piles.
4. To strengthen and constringe relaxed parts; as in prolapsus.
5. To subdue inflammation of superficial parts. When used for this purpose, they are sometimes called *repellents* or *repercussives* (*repellentia* seu *repercutientia* vel *reprimentia*). The most successful method of treating mucous and purulent inflammation of the conjunctiva is by the use of astringents, especially of nitrate of silver. This constitutes what is commonly termed the *stimulant* method of treatment. The astringents act first chemically, and then dynamically: the vessels and other tissues of the part are constringed, and their vital properties beneficially influenced. In erysipelas also, nitrate of silver is sometimes of considerable utility. In acute rheumatism and gout, the pain, redness, swelling, and stiffness of the affected joint are greatly relieved by the use of an iodine paint.

ORDER 3. ANTIDOTA.—Agents which alter the chemical nature of poisons, and either render them completely inert or greatly diminish their activity, are denominated *chemical antidotes* (αντίδοτα) or *counter-poisons*.

In the treatment of cases of poisoning, the therapeutical indications to be fulfilled are several:—

1. The most important is the removal of the poison from the part to which it has been applied. From the *stomach* it is removed by the stomach-pump, by the use of emetics, by tickling the throat with the finger or a feather dipped in oil, and, in the case of irritant poisons, by promoting vomiting, by diluents and demulcents. In corrosive poisoning (as by strong acids and alkalies), the use of the stomach-pump is dangerous. As house or domestic emetics, a dessertspoonful of flour of mustard, or a tablespoonful of common salt, stirred up in a tumblerful of water, or strong soap-suds, may be used. But the more effective emetics are one or two scruples of sulphate of zinc, or five to fifteen grains of sulphate of copper. In their absence, a scruple or half a drachm of powdered ipecacuanha, or even two or three grains of emetic tartar, may be administered. The emetic should be given in a glass of warm water, and repeated in a quarter of an hour if it have not operated. From the *bowels* the poison is best removed by the use of castor oil and laxative enemata.

2. Another indication in the treatment of poisoning is the use of the chemical neutralizers called *chemical antidotes*. These either render the poison insoluble, and thereby prevent its absorption, or convert it into a harmless soluble substance.

3. A third indication is to sheathe the living part from contact with the poison, by which not only the topical irritant action, but also the absorption, of the poison is prevented or lessened. This is effected by the agents which I have already noticed under the name of *mechanical antidotes*, (see p. 154).

4. A fourth indication is to counteract or relieve the effects of the poison. This is effected by agents which may be conveniently termed *dynamical antidotes*. Thus coffee is given to counteract the narcotism produced by opium; ammonia to relieve the depression caused by foxglove or prussic acid; opium to allay the acute pain produced by irritant poisons, &c.

5. A fifth indication is to promote the speedy removal of the poison from the system after its absorption. Most poisons are absorbed into the blood, and are subsequently expelled from the system by the excreting organs, (see pp. 101 and 102); but it is very doubtful whether we have any means of accelerating their elimination. Orfila[1] has recommended diuretics (white wine and water, Selters water, and nitrate of potash), as did, in

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[1] *Traité de Toxicologie*, t. i. pp. 20 and 369, 4me édit. 1843.

ancient times, Celsus[1]; but this plan has completely failed in a case of poisoning by arsenic[2], in which, as in many other instances, there was complete suppression of urine. In the case of arsenic, Flandin[3] thinks that the poison is eliminated by the mucous membrane of the alimentary canal; and he, therefore, suggests that, to prevent a second absorption, the use of purgatives and chemical antidotes should be continued for a longer period than usual, and, perhaps, to the end of the malady.

The following is a list of the substances reputed as antidotes :—

Metals.

Iron filings.
Zinc filings.

Acids.

Tannic acid.
Acetic or
Citric acid.

Salts.

Alkaline or earthy sulphates.
Chloride of sodium.
Hypochlorite of soda or of lime.

Alkalines.

Ammonia.
Carbonates of ammonia.
Carbonates of soda.
Magnesia.
Carbonate of magnesia.
Lime water.
Chalk.
Soap.

Sulphurets.

Sulphuretted hydrogen (dissolved in water).
Sulphuret of potassium.

Haloids.

Chlorine.

Metallic oxides.

Hydrated sesquioxide of iron.
Mixed oxides of iron.

Organic substances.

Albuminous substances (albumen, casein, and gluten).
Starch.
Oil.

Animal charcoal[4].

It has been well observed by Mr. Alfred Taylor,[5] that "objections might be taken to many of the substances contained in the list of antidotes: for the efficacy of some of them in neutralizing the effects of the poison is questionable."

The following is a table of poisons and reputed antidotes, with the forms in which the latter can be most readily obtained and employed :—

POISONS.	*Forms.*	ANTIDOTES.	*Form of Exhibition.*
Mineral acids....	Sulphuric .... Sulphate of indigo.. Nitric .... Muriatic .... Nitro-muriatic	Alkalines .... Fixed oils	Magnesia with milk. Chalk (or whitening) with milk. Soap suds. Diluted solution of carbonate of soda. Almond, olive, or lamp oil.
Vegetable acids ..	Oxalic .... Tartaric........... Sal acetosellæ (quadroxalate of potash) .	Chalk............	Chalk (or whitening) with water.
Hydrocyanic acid	Diluted hydrocyanic acid .... Cyanide of potassium Essential oil of almonds............ Bitter almond water Laurel water	Ammonia and its carbonate	Carbonate of ammonia and water to be swallowed. Diluted ammonia to the nostrils. Artificial respiration of air impregnated with the vapour of ammonia.
		Mixed oxides of iron?............	Dissolve ten grains of sulphate of iron in one ounce of water, and add one drachm of tinct. muriate of iron; to this solution add one scruple of carbonate of potass, previously dissolved in one or two ounces of water. Administer the mixture immediately.
		Chlorine?	A few drops of a solution of chlorine, or nitro-muriatic acid, mixed with water, to be introduced into the stomach.

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[1] *De Medicina*, lib. v. cap. 27.

[2] Flandin, *Traité des Poisons*, t. i. p. 331, Paris, 1846.

[3] *Op. cit.* pp. 585-6.

[4] The admission of charcoal among chemical antidotes may perhaps be objected to. But, as Dumas has observed (*Traité de Chimie*, t. i. p. 450), the decolorizing property of charcoal is strongly influenced by, if indeed it ought not to be entirely attributed to, ordinary chemical forces;" and the antidotal property of charcoal seems referable to the same category as its decolorizing property.

[5] *On Poisons*, p. 85, 1848.

POISONS.	*Forms.*	ANTIDOTES.	*Form of Exhibition.*
Alkalies	Potash Soda Ammonia and their Carbonates	Acetic acid or	Vinegar and water, p. æ. Water, acidulated with acetic or pyroligneous acid. Sour beer.
		Citric acid	Aqueous solutions of citric acid. Lemon, orange, or lime juice.
		Oil	Almond, olive, or lamp oil.
Earths	Caustic lime	Carbonic acid	Bottle soda water.
Barytic salts	Chloride of barium (muriate of baryta) Nitrate of baryta Carbonate of baryta	Alkaline or earthy sulphates	Solution of sulphate of magnesia, or of sulphate of soda, or of alum. (For carbonate of baryta, a mixture of sulphate of magnesia and vinegar diluted. —A. S. Taylor.)
Arsenic	Arsenious acid Arsenites Arsenic acid	Lime water?	A mixture of oil and lime water, or milk and lime water.
		Hydrated magnesia?	Light magnesia mixed with water.
		Hydrated sesquioxide of iron?	Gelatinous hydrated sesquioxide of iron. A mixture of tinct. muriate of iron, or persulphate of iron, supersaturated by carbonate of ammonia. Ferri sesquioxydum (ferri carbonas) mixed with water.
		Animal charcoal	Purified animal charcoal. Common animal charcoal. Ivory black.
Antimony	Emetic tartar	Tannic acid	Solution of tannic acid. Astringent decoctions (as of tea, nutgalls, cinchona, oak-bark, pomegranate, tormentilla or uva ursi). Astringent tinctures (as of cinchona, catechu, or kino) diluted with water. Astringent extracts dissolved in water.
	Sesquichloride or butter of antimony	Alkalines	See Mineral acids.
Mercury	Corrosive sublimate Nitrate of mercury	Albuminosa	White of egg diffused in water. Yolk of egg diffused in water. Milk. Wheat-flour mixed with water.
		Iron and zinc	A mixture of two parts of finely-divided iron (filings) and one part of zinc.—(Bouchardat.)
Copper	Sulphate Verdigris	Albuminosa	See Mercury.
Zinc	Sulphate Acetate Chloride	Albuminosa	See Mercury.
		Alkalines	See Mineral acids.
Silver	Nitrate	Chloride of sodium	Common salt dissolved in water. Sea water.
		Albuminosa	See Mercury.
Lead	Oxides Carbonates Soluble salts	Alkaline or earthy sulphates	See Barytic salts. (For carbonate of lead, a mixture of sulphate of magnesia and vinegar diluted.—A. S. Taylor.)
		Hydrosulphurets	A solution of sulphuretted hydrogen, or Harrowgate water, to be drank. Painters, workmen in lead factories, and others, whose skin is impregnated with lead, should employ, as a sulphurated bath, a solution of four ounces of sulphuret of potassium in thirty gallons of water.
Tin	Chloride (spirit of tin)	Albuminosa	See Mercury.
		Alkalines	See Mineral acids.
Iodine	Solid iodine Tincture of iodine	Starch	Decoction of starch (wheat-starch, arrow-root, or tapioca). Flour and water. Boiled potatoes. Bread.
Opium Vegetable alkaloids and their salts Vegetables whose active principles are alkaloids, as belladonna, hyoscyamus, stramonium, colchicum, veratrum, &c.		Tannic acid	See Emetic tartar.
		Animal charcoal	See Arsenic.
Sulphuretted hydrogen Hydrosulphuret of ammonia (sulphuret of ammonium) Sulphuret of potassium		Chlorine	Air slightly impregnated with chlorine to be inhaled.
		Hypochlorite of soda	Dilute solution of chloride [hypochlorite] of soda to be swallowed.
		Hypochlorite of lime	Dilute solution of chloride [hypochlorite] of lime to be swallowed.

ORDER 4. DISINFICIENTIA.—Chemical agents which absorb or destroy putrescent effluvia, organic fetors, and miasmata, are called *disinfectants* (from *dis*, signifying separation, and *infect*).

The following substances have been used as disinfectants:—

Chlorinium.
Acidum nitroso-nitricum.
Acidum sulphurosum.
Calx.
Sodæ hypochloris.
Calcis hypochloris.
Plumbi nitras.
Plumbi acetas.
Zinci chloridum.
Ferri acetas *vel* sesquichloridum.
Carbo animalis.
Carbo vegetabilis.

The constituents of animal and vegetable putrescent vapours have been thus arranged and distinguished by Dr. Leeson[1]:—

Dangerous but inodorous.	*Odorous but slightly offensive.*	*Most offensive.*
Remittent miasmata.	Ammonia.	Sulphuretted hydrogen.
Typhoid miasmata.	Carburetted hydrogen.	Phosphuretted hydrogen.
Carbonic oxide.	Cyanogen.	Hydrosulphate of ammonia.
Carbonic acid.	Sulpho-cyanogen.	

These, however, are not the sole constituents of putrescent vapours; for many organic substances evolve, during putrefaction, odours not referable to any of the above-mentioned substances.

Disinfectants act more or less energetically on fetid and offensive effluvia, whose unpleasant odour they destroy: they are, therefore, *de-odorizers* (*nidorem purgantia vel tollentia*); and by analogy, they are presumed to act on and render inert miasmata; but their efficacy in this way is oftentimes very equivocal.

Charcoal absorbs putrescent effluvia. Lime absorbs carbonic acid, sulphuretted hydrogen, and, perhaps, other noxious substances. It is extensively employed, in the form of lime-wash, for the walls of buildings. Chlorine acts on organic vapours and gases chiefly by its affinity for hydrogen, with which it unites and forms hydrochloric acid. It decomposes sulphuretted hydrogen, ammonia, hydrosulphuret of ammonia, phosphuretted hydrogen, and some other fetid and offensive vapours. It is used for fumigation (*fumigatio chlorinii, oxymuriatica*, seu *Guytoniana*); but, in many instances, it has been found to be inert with respect to miasmata, while it is itself an irritating, offensive, and corrosive substance. The hypochlorites destroy offensive odours, decompose sulphuretted hydrogen, ammonia, and hydrosulphuret of ammonia. A solution of the hypochlorite of soda constitutes the disinfecting liquid of Labarraque (*liqueur de Labarraque*). Nitrous fumes act by their oxydising power. They are sometimes used for fumigation (*fumigatio nitrosa* seu *Smithiana*). Though they destroy many putrescent odours and decompose several of the gases evolved by putrefying animal matters, their corrosive and irritating qualities preclude their frequent employment. Several metallic salts are useful de-odorizers, and are termed disinfectants. They react on sulphuretted hydrogen and the hydrosulphurets, forming insoluble, inodorous, metallic sulphurets; and they unite with animal matters, and check putrefaction. They are, therefore, said to act as disinfectants *by fixation*. A solution of nitrate of lead (in the proportion of about one drachm of the salt to a fluidounce of water) constitutes *Ledoyen's disinfecting fluid*. The acetate or subacetate of lead may be employed as a substitute for the nitrate. A solution of chloride of zinc constitutes *Burnett's disinfecting fluid*; but its power of decomposing sulphuretted hydrogen is very limited. A solution of a persalt of iron is said to constitute *Ellerman's de-odorizing fluid*. A solution of sulphate of copper is applicable as a disinfectant. Sulphurous acid gas is a deoxidizing agent which destroys the colour and odour of many organic substances. It also has been used as a disinfectant. Besides the foregoing, other agents have also been employed as disinfectants. Thus the late Dr. Henry[1] has apparently shown, that infectious matter of certain diseases (as scarlatina) is either dissipated or destroyed by a temperature not below 200° F.; and he, therefore, suggested that infected clothing, &c. may be disinfected on this principle; for he found that neither the texture nor colour of piece goods and other articles of clothing were injured by a temperature of 250° F.

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[1] *Parliamentary Report*, in *Pharmaceutical Journal*, vol. vii. p. 113.

To disguise unpleasant odours, fumigations with balsamic and resinous substances (*e. g.* benzoin, styrax, olibanum, amber, mastic, &c.) camphor, cascarilla, &c. are sometimes employed (*fumigatio balsamica* seu *aromatica*). For this purpose *fumigating pastilles* are used. The fumes of burning lavender, brown paper, &c. are employed in the sick chamber for a similar purpose. None of these substances destroy chemically noxious effluvia: they merely overpower or disguise them. Ventilation is the most important disinfecting process.

ANTISEPTICA; *antiseptics* (from ἀντί, *against*; and σηπτικός, *putrefying*) or *antiputrescents*. These are substances which check or prevent putrefaction. Though really distinct in their object, they are often confounded with the disinfectants, because the same agents not unfrequently act both as antiseptics and disinfectants.

Putrefaction, properly so called, is a process peculiar to dead organic matter; and the agents, which check or prevent it, act physically or chemically. Warmth, air, and water, powerfully promote putrefaction; and their exclusion, therefore, are among the most effective antiseptic means. Thus cold, exclusion of atmospheric air, and desiccation, are good preservers of dead organic matters. A vacuum, gases which do not yield oxygen to organic matter, and coatings of oil, butter, tallow, wax, resin, and syrup, act by excluding air. Exposure to the temperature of boiling water has a remarkable influence in preventing fermentation and putrefaction; and on this, as well as on the exclusion of air, is founded Appert's method of preserving provisions.[2] Lastly, certain chemical agents, by contact with organic matter, check or prevent fermentation and putrefaction: these are the antiseptics properly so called, or *chemical antiseptics*.

The following is a list of the chemical antiseptics in most frequent use:—

Chlorinium.
Acidum nitrosum.
Acidum sulphuricum.
Acidum sulphurosum.
Acidum arseniosum.
Sodii chloridum.
Potassæ nitras.

Alum.
Potassæ chromas.
Hydrargyri bichloridum.
Zinci chloridum.
Ferri sulphas.
Cupri sulphas.
Alcohol.

Spiritus pyroxylicus.
Creasoton.
Olea ætherea.
Olea empyreumatica.
Acidum tannicum.
Saccharum.

These antiseptics operate as such in different ways:—

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[1] *Philosophical Magazine and Annals of Philosophy*, for January 1832, vol. xi. pp. 22 and 205.

[2] *The Art of Preserving all kinds of Animal and Vegetable Substances for several Years*, by M. Appert, translated from the French, 2d edit. Lond. 1812.

1. Some abstract water from the organic matter: as sugar.

2. Some act by forming with the organic matters compounds less susceptible of decay: as sulphuric acid, alum, arsenious acid, bichloride of mercury, chloride of zinc, sulphates of iron and copper, tannic acid, and creasote.

Alcohol, pyroxylic spirit, common salt, nitrate of potash, and some other substances, appear to act in a twofold capacity: they both abstract water from, and form chemical compounds with, the organic matter.

3. Some act as deoxidizing agents; as sulphurous acid.

4. Some appear to act by their destructive influence on cryptogamic plants and infusory animals; as arsenious acid and bichloride of mercury (which also act chemically, as before mentioned). To these may probably be added the volatile and empyreumatic oils.

Antiseptics are of great service in the preservation of provisions and of anatomical preparations; but, as therapeutical agents, they are of little importance. They are sometimes employed to check the putrefaction of dead parts in gangrene, necrosis, and caries.

Besides the physical and chemical agents above mentioned, another class of substances has been termed antiseptics. Certain diseases, formerly denominated putrid, were supposed to depend on a putrescent or decomposed condition of the solids and fluids, characterised by the loose texture of the crassamentum, petechiæ, and an offensive condition of the excretions. Remedies which relieved this state were called antiseptics. Guersent denominates them *physiological antiseptics*.[1] But the alterations which are observed in the characters of the solids and of the blood in the above maladies have no apparent analogy with those which attend the putrefaction of dead animal matters; and accordingly modern pathologists have rejected the doctrine of putrescency of the fluids. Liebig[2] has endeavoured to revive the old notion; but, though his reasoning is ingenious, it is any thing but satisfactory.

Class III. *Topica Dynamica*. Topical Medicines acting Dynamically.

The dynamical agents used as topical remedies may be conveniently arranged in two sub-classes; the one including the *acrids*, the other the *emollients*. The former irritate or excite; the latter soothe and lessen excitement. A third sub-class, including those topical agents which diminish sensation, might be admitted; but they will be hereafter noticed in the class *neurotica*.

Sub-class 1. *Acria*. Acrids.

The substances called *acrids* stimulate, irritate, or inflame the living parts with which they are placed in contact, independently of any known chemical action. They are, therefore, irritants; and, to distinguish them from those which act chemically, they may be denominated *dynamical irritants*.

The following is a list of the acrids most frequently employed in medicine as external topical agents:—

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[1] *Dictionnaire de Médecine*, art. *Antiseptique*.

[2] *Organic Chemistry in its Application to Agriculture and Physiology*, edited by Lyon Playfair, Ph.D. London, 1840. Also, *Animal Chemistry*, edited by Dr. Wm. Gregory, 3d edit. 1846.

1. VEGETABLE.

CRUCIFERÆ.
Sinapis alba—*Seminum pulvis.*
Sinapis nigra—*Seminum pulvis.*
Cochlearia Armoracia—*Radix.*

TEREBINTHACEÆ.
Amyris elemifera—*Resina.*

COMPOSITÆ.
Anacyclus Pyrethrum—*Radix.*

SOLANEÆ.
Capsicum annuum—*Baccæ.*

THYMELACEÆ.
Daphne Mezereum—*Cortex.*

EUPHORBIACEÆ.
Euphorbia—? *Resina.*
Croton Tiglium—*Oleum.*
URTICEÆ.
Piper nigrum—*Baccæ.*
CONIFERÆ.
Pinus }
Abies } *Terebinthina, oleum terebinthinæ, resina.*
Larix }
SCITAMINEÆ.
Zingiber officinale—*Radix.*
LILIACEÆ.
Allium sativum—*Bulbus.*
Allium Cepa—*Bulbus.*

2. ANIMAL.

Cantharis vesicatoria.

3. INORGANIC.

Antimonii potassio-tartras.

The vegetable acrids were formerly supposed[1] to owe their activity to a peculiar proximate principle, which was denominated the *acrid principle of plants (principium acre plantarum)*; but modern chemistry has shewn that there is no one constituent of organic substances to which this term can be exclusively applied; but that many dissimilar principles agree in possessing acridity. Thus acrid substances are found among *acids* (*e. g.* gambogic), *vegetable alkalis* (*e. g.* veratria and emetia), *neutral crystalline matters* (*e. g.* elaterin), *volatile oils* (*e. g.* cantharidin, and the oils of mustard, garlic, and rue), *resins* (*e. g.* the resins of euphorbium and mezereon), and *extractive matter* (*e. g.* colocynthin). The acrid matter of some plants (*e. g.* of ranunculus) has not yet been isolated. This probably arises from the facility with which it becomes decomposed.

The acrid principles in general readily become absorbed, circulate with the blood, and are thrown out of the system by the secreting organs. On both the vascular system and secreting organs they act as stimulants.

The acrids are employed as topical agents for various purposes:—

1. To stimulate or irritate the skin (*cutaneous stimulants*) for the purpose of effecting counter-irritation (see p. 123). When used to produce redness merely, they are termed *rubefacients* (*rubefacientia*). For this purpose mustard poultices are frequently applied externally to relieve internal inflammatory affections. Ginger, pepper, onions, garlic, and turpentine, are also employed for the same purpose. Sometimes they are used as *vesicants* or *epispastics* (*vesicantia* seu *epispastica*); that is, to cause the exhalation of a thin serous fluid under the cuticle. Cantharides are generally employed for this purpose: though mezereon, euphorbium, and some of the chemical irritants (as acetic acid and ammonia) are occasionally used for the same object. Lastly, some of the acrids produce a crop of pustules, when they are termed *suppurants* (*suppurantia*). Croton oil and emetic tartar are of this kind. The latter, perhaps, acts chemically as well as dynamically.

2. To stimulate ulcerated surfaces (*ulcer stimulants*). Surgeons employ

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[1] See the *Principles of Modern Chemistry systematically arranged*, by Dr. F. C. Gren., translated from the German, vol. i. p. 428, Lond. 1800. Also Gura, *De Principio Plantarum acri*, Halæ, 1791.

a variety of topical applications to ulcerated surfaces for the purpose of augmenting or altering the vital activity of the part.

Sub-class 2. *Medicamenta Emollientia.* Emollients.

(Demulcents.)

Topical agents which diminish the tone or insensible contractility of the living tissues, and thereby cause relaxation and weakness, are denominated *emollients* (from *emollio*), I soften).

The following is a list of the most frequently employed emollients:—

1. VEGETABLE.

- Papaveraceæ.
  - Papaver somniferum—*Semina.*
- Lineæ.
  - Linum usitatissimum—*Semina, oleum.*
- Malvaceæ.
  - Malva sylvestris—*Herba.*
  - Althæa officinalis—*Radix, folia.*
- Leguminosæ.
  - Acacia vera—*Gummi arabicum.*
  - Astragalus—*Gummi tragacantha.*
  - Glycyrrhiza glabra—*Radix, extractum.*
- Pomaceæ.
  - Cydonia vulgaris—*Semina.*
- Amygdaleæ.
  - Amygdalus communis—*Semina, oleum.*
- Compositæ.
  - Tussilago Farfara—*Folia.*
- Oleaceæ.
  - Olea europæa—*Oleum.*
- Euphorbiaceæ.
  - Janipha Manihot—*Tapioca.*
- Artocarpeæ.
  - Ficus Carica—*Fructus.*
- Smilaceæ.
  - Smilax—*Radix sarzæ.*
- Palmaceæ.
  - Elais guineensis—*Oleum palmæ.*
  - Sagus Rumphii—*Sago.*
- Gramineæ.
  - Triticum vulgare—*Semina.*
  - Hordeum distichon—*Semina.*
  - Avena sativa—*Semina.*
  - Saccharum officinarum—*Saccharum.*
- Lichenes.
  - Cetraria islandica.

2. ANIMAL.

- Lac.
- Ichthyocolla.
- Cornu cervi—*Gelatina.*
- Mel.
- Butyrum.
- Axungia.
- Adeps ovillus.
- Cetaceum.
- Cera.
- Ovi albumen et vitellus.

3. INORGANIC.

- Aqua tepida.
- Vapor calidus.

Emollients have an operation diametrically opposite to tonics, especially to those which are astringent. They relax, soften, and swell the tissues, and render them more flexible. Applied to inflamed parts, they diminish heat, tension, and pain, and oftentimes assist in producing the resolution of the disease; and when the inflammation is too violent, or too far advanced, for this to be effected, they are useful by promoting suppuration (see pp. 14 and 22). They have a relaxing effect on the muscular fibre, and are, therefore, employed to relieve spasm. These effects have been referred by some to a physical, by others to a vital agency. During life the particles of the body are kept in approximation by two forces—attraction and the vital principle; and as emollients render the parts to which they are applied soft and flexible, that is, they produce relaxation, it becomes a question whether they operate by overcoming the cohesion of the molecules, or by modifying the vital properties. Most writers have regarded them as mechanical agents, and explain their influence just as they account for the action of warm water, or oil, on inorganic substances—leather, for example. But we should always be cautious in applying physical explanations to vital phenomena; and in the present instance this is particularly necessary. Emollients act physically on inorganised parts of the body (the cuticle, for example); but, on living parts, they exert another kind of influence; for cold water, which diminishes the cohesion of dead parts, and renders them softer and more flexible, has not the same effect on living tsssues. Moreover, Dr. A. Crawford[1] has shewn that some medicinal agents which diminish the cohesion of dead animal tissues have an opposite effect on the living ones.

The constitutional effects of emollients are for the most part those of nutrients, not of medicines; though the continued use of some is said to diminish the tone or vigour of the system generally; an effect ascribed by Barbier[2] to their absorption and local action on all the fibres of the body. This statement, however, is unsupported by fact in the case of gum, starch, sugar, gelatine, albumen, and some other principles.

Emollients are used to prevent the action of irritating matters on the body, by involving them, or by sheathing or defending surfaces from substances capable of operating on them injuriously. When used for these purposes, they are denominated *demulcents* (*demulcentia*, from *demulceo*, I mitigate or soften). Thus we administer them when acrid poisons have been swallowed. They are applied externally, in the form of local baths, poultices, fomentations, &c. both as emollients and demulcents, in local inflammations, painful ulcers, &c. In irritation, inflammation, and ulceration of the alimentary canal (as in gastritis, enteritis, diarrhœa, dysentery, &c.) they are taken either by the mouth or in the form of clyster. In catarrh, peripneumony, and pulmonic affections in general, where the cough is dry and harsh, and the expectorated matters are acrid, the use of emollients is often attended with very beneficial effects. By their lubricating and soothing influence over the nerves distributed to the fauces, they probably affect the bronchial membrane and pulmonic structure by a reflex action. In affections of the urinary passages, as ardor urinæ, aqueous drinks are very serviceable.

Water and *oily substances* are, perhaps, the essential emollient principles. For though *gum*, *starch*, *sugar*, *albumen*, and *gelatine*, are so termed, they do not act as such unless water be present. The properties of these principles will be described in other parts of this work.

Emollients may be arranged in the following orders:—

ORDER 1. AQUOSA. *Aqueous emollients.*—This order contains water, the principal and most important substance of the class. In order, however, that it may act as an emollient, it must have a certain temperature; for neither very cold nor boiling water has any emollient effect. Dr. Cullen fixes 62° F. as the lowest temperature at which this fluid can be emollient; and observes, that the greater its warmth the greater will be its emollient power, provided that pain or scalding be not produced. Aqueous vapour is, for two reasons, more emollient than liquid water: in the first place, it penetrates the organic tissues more powerfully; and, secondly, a greater degree of heat can be applied by it than by liquid water. Dr. Cullen was doubtful whether advantage could be gained by any addition made to water.

ORDER 2. MUCILAGINOSA. *Mucilaginous emollients.*—This group has been subdivided into the pure mucilaginous emollients (as gum arabic, tragacanth, mallow, marshmallow, &c.); the sweets (as figs); the bitters (as *cetraria islandica*, coltsfoot, and sarsaparilla); and the oily (as linseed, sweet almonds, poppy seeds, &c.)

ORDER 3. AMYLACEA. *Amylaceous emollients.*—This order includes starchy or farinaceous substances; as wheaten flour, oatmeal, barley, arrow-root, sago, tapioca, wheat-starch, &c.

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[1] *An Experimental Inquiry into the Effects of Tonics, &c.*, 1816.

[2] *Traité Elémentaire de Matière Médicale*, t. ii. 2nde éd. Paris, 1824.

ORDER 4. SACCHARINA. *Saccharine emollients.*—This order consists of the saccharine substances; as ordinary sugar, honey, liquorice, &c.

ORDER 5. OLEOSA. *Oleaginous emollients.*—This order includes the waxy, fatty, and oily substances; such as the animal fats, &c. (as lard, mutton suet, butter, wax, and spermaceti), and the vegetable oils (as olive, almond, palm, linseed, &c.)

ORDER 6. ALBUMINOSA. *Albuminous emollients.*—This includes the white and yolk of egg, and milk. Saliva and gastric juice are employed on the continent for medical purposes.

ORDER 7. GELATINOSA. *Gelatinous emollients.*—This order comprehends the gelatinous substances; as gelatine in its pure form, isinglass, hartshorn shavings, &c.

Class IV. *Hæmatica.* Medicines acting on the Blood.

Medicines which are supposed to act as therapeutical agents by effecting changes in the condition of the blood are denominated *hæmatica* (αἱματικά, from αἷμα, *the blood*).

I have already had occasion to notice the alterations produced in the properties of the blood by medicines introduced into the circulation (see p. 107, *et seq.*) These are effected by a physical, a chemical, or a dynamical agency.

a. Medicines acting Physically on the Blood.

Under this head I shall notice those agents which alter the specific gravity of the plasma.

ORDER 1. DILUENTIA. *Diluents.*—These are agents which lower the specific gravity of the plasma by increasing the proportion of its fluid parts.

Aqua.	Aquosa blanda.

Aqueous fluids can alone act as diluents; their effect being in reality due to the water which they contain.

The rapid introduction of water into the circulation, either by injection into the veins or by absorption from the alimentary canal, lowers the specific gravity of the plasma, checks absorption (see pp. 103 and 132), and promotes the action of the secreting and exhaling organs (kidneys, skin, and pulmonary surface).

A diminution in the specific gravity of the plasma is attended with an important endosmotic effect; namely, enlargement or distension of the blood-corpuscles, (see pp. 92, 93, and 108). This fact was first noticed by Hewson.[1]

The thirst and desire for aqueous fluids evinced by patients labouring under fever are well known. Are these phenomena connected with the altered condition of the blood (*hypinosis sanguinis*, Simon[2])? Under the various names of slops, ptisans, thin diet, fever diet, broth diet, &c. diluents are employed in fevers to quench thirst and promote the action of the secreting and exhaling organs; while the small quantity of nutriment contained in some of them contributes to the support of the system.

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[1] *The Works of Wm. Hewson*, F.R.S. edited by G. Gulliver, p. xlvi. Lond. 1846.

[2] Simon's *Animal Chemistry*, translated by Dr. Day, vol. i. p. 287. *Hypinosis*, from ὑπό, *under;* and ἴς, ἰνός, *the fibrin of blood.* In this condition of blood, the quantity of fibrine is frequently less than in health, while the quantity of corpuscles is either absolutely or relatively increased; and the quantity of solid constituents is also frequently larger than in the normal fluid. Moreover, in the contagious fevers, the blood is probably the seat of a morbid poison.

ORDER 2. INSPISSANTIA. *Inspissants.*—These are agents which augment the specific gravity of the plasma.

There are two modes of increasing the density of the plasma: the one is by withholding or diminishing the use of alimentary fluids; and the other is by the employment of evacuants (hydragogues, diuretics, and diaphoretics), which carry off part of the watery portion of the blood.

Restriction in the amount of fluids taken, or, in other words, the use of a *dry diet*, is practised in the following cases:—

α. When our object is to lessen the volume of the circulating fluid; as in valvular diseases of the heart.

β. When we desire to promote the coagulation of the blood. Thus, in aneurism of the aorta, and other large vessels, our hope of cure depends on the coagulation and deposition of the fibrine of the blood within the aneurismal sac. In such cases we endeavour to increase the specific gravity of the plasma.

γ. When we are desirous of repressing excessive secretion. Thus, in hydruria and diabetes, an important part of the treatment consists in the restriction of the use of drinks. So also in coryza, and probably other catarrhal affections, total abstinence from liquids (constituting the *dry treatment*) for a couple of days is an effectual, though not very agreeable, method of cure.[1]

By the use of evacuants (such as hydragogues, diuretics, and diaphoretics), a discharge of the watery part of the blood is effected, and the density of the plasma thereby increased. In consequence of this, and by an action of exosmose, the blood-corpuscles are emptied of part of their contents, and become in consequence somewhat collapsed and shrivelled.[2] In diseases characterised by excess of water in the blood (*spanæmia*, Simon[3]), as anæmia, as well also in morbus Brightii, the employment of purgatives to carry off water from the blood constitutes an important part of the treatment.

The injection into the blood of saline solutions, having a specific gravity greater than that of the serum (1·027 or 1·028) causes shrivelling or collapse of the corpuscles. This fact was first ascertained by Hewson.

β. Medicines acting Chemically on the Blood.

A considerable number of medicines produce a more or less transitory chemical change in the blood.

Some of them diminish the amount of the solid constituents (especially the fibrin and corpuscles) of the blood, and thus give rise to that condition of the circulating fluid called by Simon spanæmia, or poverty of the blood; others augment the number of blood-corpuscles or the amount of hæmatin in the blood. The former may be conveniently termed *spanæmica;* the latter, *hæmatinica.*

ORDER 3. SPANÆMICA (σπαναιμικά, from σπανός, *poor*; and αἷμα, *blood*: *antiplastic alteratives* or *dysplastica*, Oesterlen: *plastilytica* and *erethi-*

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[1] Dr. C. J. B. Williams, *Cyclopædia of Practical Medicine*, art. *Coryza*; also, *Lond. Med. Gaz.* vol. xxi. p. 676, for Jan. 27, 1838.

[2] See *ante*, p. 92. Also, Dr. Rees, in *Lond. Med. Gaz.* vol. xxxv. p. 849, April 4, 1845.

[3] *Animal Chemistry*, vol. i. p. 306.

lytica (hæmatolytica), Schultz: *dyscrasiaca*). Spanæmics are agents which, by long-continued use, impoverish the blood.

This order includes iodine and bromine, most of the metals (not iron), the acids (commonly so called), the alkalines, and the alkaline and earthy salts.

They act topically as chemical irritants. They become absorbed, and are afterwards readily detected in the excretions. Their long-continued use in moderate doses injures digestion, assimilation, and sanguification; and gives rise to a state of dyscrasy or cachexia. Their effects in many cases *accumulate;* and hence arise the phenomena of *saturation* (see *Lead* and *Mercury*). In excessive doses they act as caustic and irritant poisons.

They are important therapeutic agents, and serve numerous useful purposes in medicine. But, these being very varied, and their therapeutic properties in some cases opposed (*e. g.* the acids and alkalies), I shall reserve my notice of their remedial uses to the subdivisions of the order. As topical remedies, they have already been spoken of, (see *Topica Chemica*).

The spanæmics may be conveniently arranged in four sub-orders: one, including the mineral and vegetable acids, which quench thirst and lessen preternatural heat *(sp. adipsa et refrigerantia);* a second, comprehending the alkalines, iodine, bromine, sulphur, the salts, mercurials, and antimonials, which act as resolvents and liquefacients *(sp. resolventia seu liquefacientia);* a third, containing the preparations of arsenic, copper, zinc, silver, and bismuth, which are employed in the treatment of certain morbid affections of the nervous system of a spasmodic nature *(sp. antispasmodica);* and the fourth, consisting of the preparations of lead, employed for their astringent and sedative properties, and which, in poisonous doses, excite palsy *(sp. saturnina).*

SUB-ORDER *a.* SPANÆMICA ADIPSA ET REFRIGERANTIA *(hæmatolytica physoda*, Schultz; *acida; antalkalina)*.—The thirst-quenching, refrigerant spanæmics. This sub-order includes both mineral and vegetable acids.

Acida mineralia.	*Acida vegetabilia.*
Acidum sulphuricum.	Acidum aceticum.
Acidum nitricum.	Acidum citricum.
Acidum hydrochloricum.	Acidum tartaricum.
Acidum phosphoricum.	

The chemical action on the tissues and albumen of the mineral acids, as well as of acetic acid, have already been noticed, (see pp. 89 and 94). In the concentrated state they destroy both organisation and life (morpholysis and biolysis, see p. 95), and are employed as escharotics (see p. 157). The diluted acids coagulate the liquid portion of the mucus of the mucous membranes. Dilute acetic, oxalic, and tartaric acids (but not the dilute mineral acids), dissolve the capsule of the mucous corpuscles. The concentrated acids dissolve the epithelium scales; but the dilute acids do not affect them.

When sufficiently diluted, they cease to be corrosive, though they still exert a chemical influence. Thus, when applied to the skin, they harden the cuticle by uniting with its albumen; and, when applied to the mucous surfaces, they produce astriction and a slight whitening of the part (from their chemical influence on the mucus and the epithelial coat).

The diluted mineral and vegetable acids, when swallowed in moderate doses, at first allay thirst, sharpen the appetite, and promote digestion. They check preternatural heat, reduce the frequency and force of the pulse, lessen cutaneous perspiration, allay the troublesome itching of prurigo, sometimes prove diuretic, and occasionally render the urine unusually acid. Under their use, the milk often acquires a griping quality, and the bowels become slightly relaxed. By their long-continued employment, the tongue becomes coated with a whitish but moist fur, the appetite and digestion are impaired; while griping and relaxation of bowels, with febrile disorder, frequently occur. If their use be still persevered in, they more deeply injure the assimilative processes, and a kind of scorbutic cachexy is established.

The concentrated mineral acids act as corrosive poisons, and destroy both the organisation and life of the parts with which they come in contact, (see p. 95). They depress the heart's action through the agency of the nervous system, and on the principle of shock, (see p. 114).

The chemical influence of the acids in the alimentary canal is an interesting object of inquiry. Their relations to the organised tissues, albuminous liquids, and mucus, have been already alluded to. Small quantities of the dilute acids do not appear to injure the digestive powers of the gastric juice, which, in its normal state, possesses acid properties. Indeed, it is well known that, in the preparation of an artificial digestive liquor, the presence of minute portions of a free acid (hydrochloric or acetic) is necessary. It is obvious, however, that if, as Liebig[1] infers from Lehmann's experiments, the gastric juice naturally contain lactate of magnesia, this salt will suffer partial decomposition by the introduction of one of the mineral acids into the stomach. The acids unite in the alimentary canal not only with the albuminous substances and mucus, but also with the alkaline (soda) and earthy bases (lime and magnesia) found in the saliva, bile, and pancreatic juice; and in this way they become neutralized and form compounds, some of which are soluble, others insoluble: the former are absorbed, and the latter rejected.

In considering the chemical influence of the acids on the blood and on distant parts, it is important to bear in mind the fact just mentioned; namely, that the acids[2] enter the blood in combination with bases; so that they react in the stomach and alimentary canal as acids, but in the blood as salts. The impossibility of dissolving ossific deposits in distant organs by the internal administration of the acids is, therefore, readily accounted for. It is obvious, moreover, that no analogy can exist between the chemical influence of free acids added to blood after its withdrawal from the body, and that of acids combined with bases (that is, of salts,) entering the blood from the alimentary canal.

That the acids which have been administered by the mouth traverse the system, is demonstrated by the fact of their subsequent detection in the secretions, especially the urine, (see pp. 87 and 102). But, while in the blood, they must be in combination, since their acid properties are neutralized.

It must not, however, be inferred that the influence of the acids on the blood and general system is identical with that of the salts of the same acids;

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[1] *Researches on the Chemistry of Food*, edited by Dr. Gregory, p. 138, Lond. 1847.

[2] Hydrocyanic acid may possibly be an exception to this statement, since its odour has been detected in distant parts. The same, perhaps, may be the case with some other weak acids, as carbonic acid. Liebig (*Researches on the Chemistry of Food*, 1847,) ascribes the alkaline reaction of the blood, as well as the power of this fluid to take up carbonic acid, to the presence of phosphate of soda (PO^5, $2NaO$, HO).

for it must be remembered, that the acids deprive the system of part of its alkaline and earthy bases, which are employed in neutralizing and conducting the acids safely out of the system, and which, but for the administration of the latter, would have been otherwise applied to the purposes of the economy. Now these bases, though obtained directly from the saliva, the bile (chiefly), and the pancreatic juice, are indirectly derived from the blood; so that, in a secondary way at least, the acids must modify the composition of the blood.

A striking illustration of the different effects produced on the system by the vegetable acids and by their salts is derived from Wöhler's observations before noticed (p. 102). Several of the free vegetable acids, when administered by the mouth, are subsequently detected in the urine in combination with an alkali; but, when given in combination with an alkali, carbonates (bicarbonates?) of the alkali are detected in the urine. The free vegetable acid, therefore, robs the system of alkaline matter, while the salts of the same acids deprive the system of oxygen. Benzoic acid ($C^{14} H^5 O^3$), during its passage through the system, also abstracts the elements of glycocoll or gelatine sugar ($C^4 NH^4 O^3$); for it appears in the urine in the form of hippuric acid ($C^{18} N H^9 O^6$) combined with a base.

From the preceding remarks, it may be inferred that the precise changes effected in the blood by the internal administration of the acids are very obscure; nay, the very action of these bodies on the circulating fluid is rather assumed than demonstrated. The statements of authors as to the changes in the physical and chemical properties of the blood, produced by the administration of acids are, therefore, for the most part, hypothetical, as are also the pathological and therapeutical deductions therefrom. Several of them, indeed, are founded on erroneous premises. Thus, Dr. Stevens[1] states that, "when acids are used internally, some of them enter the circulation, darken the colour of the current, and reduce the force of the vascular organs; or when we add a weak acid solution to healthy blood out of the body, we make it quite as black as it is either in scurvy, cholera, or the last stage of the climate fever." Now it is obvious that Dr. Stevens's statements, respecting the effect on the blood of acids administered internally, are entirely hypothetical, and are founded on the erroneous notion that the acids enter the circulation in the free state, and that their action on the circulating blood is similar to that which they exercise on blood drawn from the body. Both of these errors I have already exposed, (see p. 171). Schultz,[2] also, has more recently fallen into similar errors. Both the acids and salts (alkaline and earthy), he says, act on the blood as biolytic[3] agents; and he, therefore, terms them hæmatolytics (*hæmatolytica*): the former, however, act on the corpuscles, and are, in consequence, called *blood-corpuscle hæmatolytics* (*hæmatolytica physoda*); while the latter exert their influence on the plasma, and are, therefore, denominated *plasma hæmatolytics* (*hæmatolytica plasmatoda*). To the action of the acids on the blood-corpuscles he ascribes their antiphlogistic power. They have, he says, an extraordinary faculty of abstracting the colouring matter from the corpuscles, and of rendering it soluble in the plasma. When thus decolorized, the corpuscles possess a very inconsiderable respiratory power; and the more they are decolorized by the use of acids and acid drinks, the weaker is the pulmonary respiration; and, therefore, after the use of acid medicines, vital excitation and calorification are lessened. Hence the reputed cooling effects of acids. The blood, therefore, continues Schultz, always becomes black after its intermixture with acids as well as by their use.

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[1] *Observations on the Healthy and Diseased Properties of the Blood*, p. 263, 1832.

[2] *Naturliches System der allgemeinen Pharmakologie*, pp. 156 and 444, 1846.

[3] I have before (p. 95) explained the meaning of the word biolytic.

The acids are thrown out of the blood by the kidneys. They probably never pass off in the free state, but always in combination with a base; and hence they do not in general increase the acidity of the urine.[1] But, even in those cases in which the urine has become preternaturally acid after the use of acid medicines, it is probable that the augmented acidity was dependent on an increase in the proportion of those ingredients which, in the healthy state, render the urine slightly acid.[2] Perhaps, therefore, in the cases now alluded to, the acids acted upon the digestive and assimilating organs, and indirectly modified the renal secretion;[3] or appropriated to themselves bases which, but for their presence, would have been eliminated in combination with the normal constituents of the urine.

A recent eminent writer[4] states, that the urine may be easily rendered acid "by any vegetable acid,—as tartaric, citric, acetic acids;" and he quotes, apparently as his authority for this assumption, Wöhler's experiments.[5] The affinity of the vegetable acids for bases being weaker than that of the mineral acids, the presence of the former in the urine, in a free state or as super-salts, appears *à priori* less improbable.[6] But it is more likely that the vegetable, as well as the mineral, acids acidify the urine by acting indirectly; namely, on the digestive and assimilating organs. As the vegetable acids, when swallowed in combination with alkalies, undergo oxidation in the system, it might be expected that the free vegetable acids would be subject to a similar change; but such does not appear to be the case; why, it is not easy to say.

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[1] Berzelius (*Traité de Chimie*, t. vii. p. 401, 1833,) observes, that the mineral acids never increase the acidity of the urine. Wöhler (Tiedemann's *Zeitschrift für Physiologie*, Bd. i. S. 138,) states, that the urine of a dog, to whom two drachms of oxalic acid had been given fasting, was not preternaturally acid, though it contained a soluble oxalate, and deposited small crystals of oxalate of lime. Practical physicians and surgeons are familiar with the fact of the difficulty, and, in many cases, impracticability, of acidifying alkaline urine. (See, on this subject, Dr. Golding Bird's observations in the *London Medical Gazette*, Jan. 22d, 1847, p. 154). Orfila (*Journal de Chimie Médic.* t. viii. 1e Sér. p. 266, *et seq.*) detected nitric, sulphuric, hydrochloric, oxalic, and perhaps acetic, acids in the urine of dogs poisoned by these substances; but in no case does it appear that these acids were in the free state.

[2] Mr. Brande (*Phil. Trans.* for 1813,) states, that when the mineral acids are given to relieve phosphatic deposits, they are apt to induce red gravel (uric acid).

[3] Berzelius (*op. cit.* p. 414) gave to a patient affected with alkaline urine, with phosphatic deposits, increasing doses of phosphoric acid without being able to acidify the urine. Ultimately the acid purged the patient, and then the urine acquired an acid character, recovered its transparency, and deposited uric acid.

[4] Dr. H. Bence Jones, *On Gravel, Calculus, and Gout*, p. 86, Lond. 1842.

[5] Wöhler's statements do not bear the construction which has been put on them. This eminent chemist experimented with oxalic, tartaric, citric, malic, gallic, succinic, and benzoic acids. In one case only (viz. in the experiment with tartaric acid), he observes, that "the urine appeared unusually acid." In the case of oxalic acid, he says, it was not more acid than usual; and, in that of succinic acid, he found it to be alkaline. The acidity or alkalinity of the urine is not stated in the cases of citric, malic, and gallic acids; though he observes that the odour, taste, and proportion of phosphate of lime of the urine appeared to him to be natural in the animals to whom citric and malic acids had been given. With respect to the benzoic acid, he observes that it was found in the urine in combination with a base. In a subsequent part of his paper (p. 307), he concludes that, "from the foregoing experiments with oxalic, tartaric, and benzoic acids, it is probable that these—and perhaps all acids—are never eliminated in the urine in the free state, but always in combination with a base."

[6] Mr. Brande (*Phil. Trans.* 1813,) says, that the vegetable acids are less apt to cause the deposition of red gravel (uric acid) in the urine than the mineral ones.

As the acids become neutralized by combination with bases before their absorption into the blood, it follows that, as free acids, they operate topically only. They are useful as such for the following purposes:—

1. As escharotics, (see p. 157).

2. As antalkalines in poisoning by the alkalies and their carbonates (see p. 161), and in some forms of pyrosis which are attended with an alkaline condition of the gastric secretion.[1]

3. As astringents and styptics in hemorrhage from the stomach and bowels. They constringe the blood-vessels of the mucous membrane of the alimentary canal, and coagulate mucus and blood.

4. As lithontriptics. Very dilute solutions of the mineral acids (hydrochloric and nitric) have been injected into the bladder as solvents for phosphatic calculi. They have proved useful in chronic inflammation of the mucous membrane of the bladder, accompanied by a deposition of the phosphates. They are serviceable in two ways,—by their solvent action on the concretions, which they assist in disintegrating; and by benefiting the condition of the mucous membrane of the bladder.[2]

The acids are also efficacious, as remote or general agents, in several cases in which their chemical influence is not very obvious. Thus they are used,—

5. To check profuse sweating in hectic fever.

6. To allay the distressing itching and irritation of the skin in prurigo and lichen.

7. To lessen preternatural heat and reduce the frequency and force of the pulse; as in febrile complaints and hemorrhages (pulmonary, uterine, &c.)

8. To relieve narcotism after the poison has been evacuated from the stomach and bowels.

9. In dyscrasies or diseases which have been supposed to depend on, or be connected with, a depraved condition of the animal fluids; as scorbutus, secondary syphilis, and mercurial cachexia.

The efficacy of vegetable acids (especially citric acid) and fresh vegetables and fruits in the treatment of scurvy is too well established by experience[3] to be affected by the hypothetical objections of Dr. Stevens[4] to the use of acids in this malady. A satisfactory explanation of their *methodus medendi* is still wanting; for though the assumption that non-nitrogenous food in scurvy is useful by acting, in the oxidizing processes of the system, as a substitute for the animal tissues which are thereby preserved, accounts for the fact[5] that the pure acids are less efficacious than acid vegetable juices,[6] yet it fails to account for various circumstances (such as the inefficacy of the fatty substances, and the occasional failure of even lemon juice to prevent or to check scurvy),[7] and, therefore, cannot be considered as a satisfactory explanation.

10. In the so-called putrid fevers, the mineral acids have frequently proved

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[1] Dr. R. D. Thomson, *British Annals of Medicine*, March 31, 1837.

[2] Sir B. Brodie, in the *Lond. Med. Gazette*, vol. viii. p. 355, 1831; Dr. Golding Bird, *Urinary Deposits*, p. 209.

[3] See Dr. Lind's *Treatise on the Scurvy*, 3d edit. Lond. 1772.

[4] *Observations on the Healthy and Diseased Properties of the Blood*, pp. 263 and 264, Lond. 1832.

[5] Dr. Budd, *Lectures on the Disorders resulting from Defective Nutriment*, in the *London Medical Gazette*, July 1842, p. 716.

[6] The acid vegetable juices contain acidulous alkaline salts, which, as before stated, suffer oxidation in the system, though the free acids do not.

[7] See my *Treatise on Food and Diet*, pp. 147 and 358.

serviceable. They were originally employed under the idea that they checked the supposed putrescent tendency of the fluids. May they not be useful by abstracting from the system basic matter?

11. In phosphatic deposits in the urine, the acids, both mineral and vegetable, are often resorted to, and occasionally with relief. They are, however, very uncertain, and, at best, are but palliative.

12. As tonics, the diluted mineral acids (especially the sulphuric) are frequently employed in conjunction with the vegetable bitters; as cinchona and quinine.

SUB-ORDER β. SPANÆMICA RESOLVENTIA SEU LIQUEFACIENTIA.—Resolvent or liquefacient spanæmics. This sub-order includes the agents which, in the last edition of this work (vol. i. p. 194), were denominated simply *liquefacientia*.

This sub-order includes the *alkalines*, *iodine*, *bromine*, *sulphur*, *mercurials*, and *antimonials*.

These spanæmics promote secretion and exhalation generally, soften and loosen textures, check phlegmonous inflammation, lessen inflammatory effusions, and promote their re-absorption. Their antiphlogistic effect is best seen after the use of mercury, the action of which, observes Dr. Farre,[1] "is positively antiphlegmonous. If it be pushed far enough, it produces an effect the exact reverse of the phlegmonous state; namely, the erythematous inflammation, the tendency of which is to loosen structure, while that of phlegmonous inflammation is to bind texture."[2] Under the influence of mercurials, the gums become spongy, the intestines and pulmonic membranes softened,[3] and deposits of coagulable lymph (as in iritis) are removed. The beneficial effects of mercurials, antimonials, iodine, alkalies,[4] &c. in promoting the resolution of visceral and glandular inflammation, and in relieving active congestion, may be ascribed to the antiphlegmonous action referred to by Dr. Farre. These agents are opposed to the exudation of plastic or coagulable lymph (hence they check union by adhesion), and to the formation of false membranes. During their use, visceral and glandular enlargements and indurations, thickening of membranes (as of the periosteum), and morbid, but non-malignant, growths of various kinds, are sometimes observed to get softer and smaller, and ultimately to disappear. Dr. Ashwell[5] graphically describes indurations and hard tumors of the uterus as having "melted away" under the influence of iodine. In hepatization of the lungs, the effused solid matter is often absorbed, and the cells rendered again permeable to air, by the use of mercury. It is on account of the influence of liquefacients in checking phlegmonous inflammation, obviating its consequences, and promoting the removal of enlargements, indurations, &c. that they are frequently denominated *resolvents* (from *resolvo*, I loosen or dissolve).

The resolvent operation of these medicines is usually explained by referring it to an augmented activity of the absorbents. But this explanation is imperfect, and does not account for all the phenomena. The effect is ascribable to a change in the nutrition of the parts affected. My, friend, Dr. Billing,[1] is of opinion that " mercury and iodine remove morbid growths by starving them, which they effect by contracting the capillaries." But I conceive there must be something more in the influence of these remedies than a mere reduction in the quantity of blood supplied to the affected parts. The enlargements which these agents remove are not mere hypertrophies; their structure is morbid, and they must, in consequence, have been induced by a change in the quality of the vital activity; in other words, by morbid action. Medicines, therefore, which remove these abnormal conditions, can only do so by restoring healthy action; that is, by an alterative influence. By what force or power they are enabled to effect changes of this kind must, for the present at least, be a matter of speculation. Müller[2] thinks it is by affinity. "They produce," he observes, " such an alteration in the composition of the tissues, that the affinities already existing are annulled, and new ones induced, so as to enable the vital principle—the power which determines the constant reproduction of all parts in conformity with the original type of the individual—to effect the further restoration and cure; the mercury itself does not complete the cure."

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[1] *Essays on the most important Diseases of Women*, by Robert Ferguson, M.D. Part i. p. 215, Lond. 1839.

[2] This statement of Dr. Farre must be received with some limitation; for, as Dr. C. B. Williams (*Principles of Medicine*, p. 280) has observed "lymph is thrown out, and granulations form, and healthy ulcers heal, during mercurial action."

[3] Ferguson's *Essays*, p. 216.

[4] Mascagni, in the *Memorie della Società Italiana delle Scienze*, Modena, 1804. Also, Nigri, in *Lond. Medical Gazette*, vol. xiv. p. 713.

[5] *Guy's Hospital Reports*, No. 1, 1836.

May not these remedies act by correcting the quality of the blood in inflammation? It is now well known that the blood in this disease contains an abnormal quantity of fibrine, the quantity of which is diminished by the use of the liquefacient spanæmics. Moreover, in buffy blood, the red corpuscles sink more rapidly than in healthy blood; a circumstance which Mr. Gulliver ascribes to their increased tendency to cluster or aggregate. Now, the salts tend to keep the corpuscles asunder; and to this cause Mr. Gulliver ascribes the efficacy of these agents in inflammation.[3] Furthermore, the blood of an inflamed part contains an increased number of white globules, which have a remarkable disposition to adhere to the walls of the vessels and to one another;[4] and it is not improbable that the beneficial effects of resolvents and liquefacients may be due to their influence in diminishing the number and adhesiveness of these globules.

1. *Alkalina. Alkalines* (*antacida; absorbentia*).—This division includes the alkalies, the alkaline earths, and the carbonates of these substances.

Potassa.
Soda.
Ammonia.
Calx.
Magnesia.

Potassæ carbonas.
Potassæ bicarbonas.
Sodæ carbonas.
Sodæ bicarbonas.

Ammoniæ carbonas.
Ammoniæ sesquicarbonas.
Calcis carbonas (*creta*).
Magnesiæ carbonas.
Magnesiæ bicarbonas.

The chemical action on the tissues of the alkalies has been already alluded to, (see pp. 89 and 94).

They dissolve albuminous substances and mucus, and saponify fatty substances. Hence, in the concentrated state, they destroy both organization and life, (see p. 95); and, when swallowed in this form, act as corrosive poisons. From their solvent action on the organic tissues, they have a softening influence even in the dilute form, and, in consequence, are saponaceous to the touch.

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[1] *First Principles of Medicine*, pp. 69, 70, 4th edit. Lond. 1841.

[2] *Physiology*, by Baly, vol. i. p. 363.

[3] *The Works of William Hewson*, F.R.S. edited, with an Introduction and Notes, by G. Gulliver, F.R.S. pp. 40 and 231 (footnotes), Lond. 1846.

[4] Dr. C. J. B. Williams, *Principles of Medicine*, p. 209, *et seq*. Lond. 1843.

When swallowed in the diluted state, they destroy the acidity of the stomach, by combining with, and thereby neutralizing, the free acids contained in this viscus. The salts thus formed are, for the most part at least, absorbed. Any excess of alkali present probably becomes absorbed in combination with albuminous matter.

They probably aid in the digestion and absorption of fatty substances, especially when there is a deficiency of bile and pancreatic juice.[1]

In small or moderate doses they promote secretion from the gastro-intestinal mucous membrane, become absorbed, act as diuretics, and communicate an alkaline quality to the urine.[2]

By repeated use, in full doses, they produce the general effects of liquefacients, already noticed (see p. 175).

Their long-continued employment disorders the functions of the digestive and assimilative organs, and gives rise to a kind of dyscrasia analogous to scurvy. The blood becomes deteriorated or spanæmic, coagulates imperfectly when drawn from a vein, and the nutrition of the body generally is impaired.[3]

The carbonates of the alkalies act less energetically, as chemical agents, on the tissues, than the caustic alkalies; the bicarbonates less than the monocarbonates.

The alkaline earths (magnesia and lime) are much less energetic, especially magnesia, in their chemical action on the tissues than the alkalies; and their carbonates (especially carbonate of lime) exert scarcely any chemical influence over the albuminous tissues.

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[1] See the experiments of Matteucci on the use of the alkali of the bile and pancreatic juice in aiding the absorption of fatty substances by forming an emulsion with them. (*Lectures on the Physical Phenomena of Living Beings*, pp. 110—113, Lond. 1847.)

[2] That the urine becomes alkaline from the employment of the alkalies and their carbonates, is a fact to which I and most practical physicians can bear testimony; but it may not be amiss to refer to some published authorities on this point. Mascagni (quoted by Wöhler) found the urine alkaline from the use of one drachm of carbonate of potash daily. Mr. Brande (*Phil. Trans.* for 1810) observed the alkalinity of the urine after the employment of the carbonates of soda and potash. He says, that two drachms of carbonate of soda rendered the urine alkaline in six minutes, and produced the full effect in a quarter of an hour, occasioning a precipitation of the phosphates of lime and magnesia, and restoring the blue colour to reddened litmus paper. Magnesia had the same effect of occasioning a precipitation of the phosphates; but, on account of its insolubility, required a greater time to produce the effect. Lime-water required five hours to produce a sensible precipitation, which, even then, was not nearly so distinct as from the alkalies. Dr. Bostock (*Medico-Chirurg. Trans.* vol. v. p. 80,) found that the urine become alkaline and effervesced with acids after the use of two ounces and a half of carbonate of soda daily.

[3] "Not a few of those who took the alcalious saponaceous hotch-potch of Mrs. Stephens, and the soap-lees, for a long time together, fell into hectical heats, a hot scurvy, hemorrhages, dysentery, &c. A remarkable instance of this lately happened to a gentleman of the West of Cornwall, who, for several years, had laboured under a stone in his bladder. He was originally of a tender constitution; and had taken the lixivium, &c. for several weeks, till at length his gums began to grow exceedingly spongy, inflamed, and livid—at last, extremely sore and putrid; insomuch, that the flesh might be pulled off with the greatest ease: they bled considerably on the least pressure; and a thin bloody ichor continually leaked off from them. Livid spots also appeared on him; and his legs, and thighs especially, became vastly sore, and of a claret colour, or rather more livid, so that a mortification was feared. Upon this I was consulted for him by Mr. Hingston, a very skilful apothecary of Penzance, who stated his case. Apprehending an alkalescent putrid state of the humours, and a dissolution of the blood from the course he had gone through and the symptoms he now laboured under, I advised the decoction and extract of the bark with elixir vitrioli, and subacid drinks and diet, which soon took off the inflammation, sponginess, and bleeding of his gums, and prevented the further advance of the livid colour of his thighs, &c. which, in a few days, disappeared. About some two or three weeks after, a copious eruption of red fiery pustules broke out upon him, which seemed to promise some advantage. However, being reduced exceedingly weak by a complication of disorders and a confirmed hectic, he died quite tabid about a fortnight or three weeks after. A very large stone was taken out of his bladder after his death." (Huxham's *Essay on Fevers*, p. 48, 3d edit. Lond. 1747).—See also the article *Ammoniæ sesquicarbonas* for an account of a case illustrating the ill effects arising from the long-continued use of large doses of this alkaline substance.

The alkalines are employed therapeutically for the following purposes:—

1. As escharotics (see p. 157).

2. As antacids or absorbents in poisoning by the acids (see p. 160), and in dyspepsia with acidity of the stomach. In the latter case, they may perhaps be serviceable in promoting the digestion of the fatty substances, where there is a deficient secretion of bile (see p. 177).

3. As softeners and cleansers of the skin, weak alkaline solutions are used as cosmetics. They exercise a solvent action on the cuticle.

4. As lithontriptics or antilithics they will be noticed hereafter (see *Lithontriptica*).

5. As diuretics they will be noticed on a future occasion (see *Diuretica*).

6. As antiplastics and resolvents in inflammation. On theoretical grounds they have been supposed useful, because their continued use leads to a diminution of the fibrine of the blood, which, in acute inflammation, is augmented in quantity; and also because coagulable lymph, a product of inflammation, is soluble in alkaline solutions. The latter observation led Mascagni[1] to propose the use of alkalies in acute inflammatory disease; and in an epidemic pulmonary affection which, in 1800, made great ravages in the district of Chiudino, in Tuscany, the practice proved highly successful, as also in dropsy induced by obstruction of the lymphatic vessels and glands, from depositions of coagulable lymph in consequence of an inflammatory diathesis.

7. As a resolvent and sorbefacient, in glandular and visceral enlargements of a non-malignant character.

8. As an alterative and antacid in rheumatic and gouty inflammation, especially when accompanied with deposits of lithic acid in the urine.

In most of the cases in which the alkalies are indicated, it will be found advisable to employ them in the carbonated state; for in this form they are less caustic, and can therefore be given in larger doses, while their remote or constitutional effects are probably equally powerful.

2. *Salia neutra et media. The alkaline and earthy salts.*—This division includes the neutral and indifferent combinations of the alkalies and earths with acids, as well as some of the acidulous or supersalts of the alkalies.

The following is a list of the officinal substances of this order:—

Inorganic.

Potassæ sulphas.
Potassæ bisulphas.
Sodæ sulphas.
Magnesiæ sulphas.
Alum.
Potassæ nitras.
Sodæ nitras.
Potassæ chloras.
Sodæ phosphas.
Sodæ biboras.
Sodii chloridum.
Ammonii chloridum.
Barii chloridum.
Calcii chloridum.
Potassii bromidum.
Potassii iodidum.

Organic (vegetable).

Potassæ acetas.
Sodæ acetas.
Ammoniæ acetas.
Potassæ tartras.
Potassæ bitartras.
Potassæ et sodæ tartras.
Potassæ citras.
Sodæ citras.
Ammoniæ citras.

The alkaline and earthy salts act both physically and chemically on the living tissues with which they are placed in contact.

Their physical or endosmotic influence has been already noticed (see pp. 91 and 92).

Their chemical influence is not very energetic, and the precise changes which they effect have not been carefully examined. The compounds which the salts form with the organic textures are more permanent, and less disposed to undergo putrefaction, than the textures alone are; and hence the salts act as antiseptics (see p. 163).

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[1] *London Medical Gazette*, vol. xiv. p. 714, Aug. 16, 1834.

All salts[1] (even common salt), when swallowed in excessive quantities, operate as irritant poisons; and some (as chloride of barium) are poisonous even in small doses.

In certain doses, most salts act as purgatives: when they do this, they are evacuated by the alimentary canal. Administered in smaller doses, they do not purge, but become absorbed, and are subsequently eliminated by the excreting organs, especially by the kidneys.[2] In this case, some of the salts (*e. g.* the alkaline acetates, citrates, and tartrates,) are oxidized during their passage through the system.

In the blood, the salts act both physically and chemically. Their physical influence on the blood-corpuscles is endosmotic (see pp. 92 and 108). When a saline solution, having a greater specific gravity than that of the serum, is introduced into the blood, the corpuscles shrink or collapse; but, when the solution is very dilute, they become distended. The chemical influence of the neutral salts is exercised both on the blood-corpuscles and on the plasma: they brighten the red colour of the former, and, in general, lessen the quantity of spontaneously coagulating matter (fibrine) in the latter.

The *antiplastic* or *plastilytic effect* on the blood of nitre and sulphate of soda has been before noticed (see p. 109). This effect of salines is, however, probably neither constant nor universal; for Laveran and Millon state that, in acute pneumonia and articular rheumatism, Rochelle salt (sodæ potassio-tartras, *Ph. L.*) given so as to become absorbed, diminished neither the quantity of fibrine nor the buffy coat of the blood.[3]

When salts are added to the blood, they lessen or destroy the adhesiveness of the corpuscles for each other, and thereby separate and render them distinct. Now, as in buffy blood the corpuscles have an increased tendency to aggregate, and to separate from the blood, Mr. Gulliver[4] suggests, that probably the efficacy of saline medicines in inflammation depends on their correcting this disordered state of the blood.

The salts are eliminated by the different excretory organs, principally by the kidneys (see pp. 101 and 102), on which they act as stimulants (see p. 110), and thus produce diuresis.

Many of them pass out unchanged (see p. 101); while others are eliminated in a more or less decomposed state (see p. 102). In the case of the neutral alkaline salts containing a vegetable acid,[5] as well as in that of sulphuret of potassium (which in part becomes converted into sulphate of potash—see p. 102), the salts suffer oxidation: but the conversion of the red ferridcyanide of potassium into the yellow ferrocyanide (see p. 102) may perhaps be regarded as a reducing process.

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[1] In the human subject, death has resulted from the use of the following salts in excessive doses:—common salt, sulphate of magnesia, cream of tartar, nitre, sulphate of potash, and binoxalate of potash. These salts are, as is well known, innocuous in small doses. We infer the poisonous operations of all salts, in certain doses, partly from observation of their effects on men and animals, and partly from analogy.

[2] Laveran and Millon, in their experiments on Rochelle salt (sodæ potassio-tartras, Ph. L.) and sulphate of soda, found that when these salts acted as purgatives absorption did not take place (*Annuaire de Chimie*, 1845, p. 585).

[3] *Annuaire de Chimie*, 1845, p. 587.

[4] *The Works of William Hewson, F.R.S.* (Notes), pp. 41, 71, 229, and 231, Lond. 1846.

[5] The alkaline oxalates are probably exceptions to this statement. After the ingestion of rhubarb-tart, or sorrel (*Rumex acetosa*), a crystalline deposit of oxalate of lime is found in the urine. Dr. Letheby (*Lond. Med. Gaz.* Jan. 22, 1847, pp. 153-4) states that he detected oxalate of urea also in the urine.

Most of the neutral alkaline salts containing a vegetable acid are converted, by oxidation, into carbonates (or bicarbonates), in which state they are found in the urine, to which they communicate an alkaline quality.[1] The acid salts are only partially decomposed: at least, this, according to Wöhler, is the case with cream of tartar: for he found that, after the use of this salt, the urine become alkaline, and, as long as it possessed this quality, it contained no tartaric acid; but, when it again became acid, tartaric acid was recognised in it.

The urine is not invariably rendered alkaline by the use of the vegetable salts of the alkalies. In 268 experiments with Rochelle salt (sodæ potassio-tartras, *Ph. L.*) Laveran and Millon found that the urine was rendered alkaline in 175 cases, was acid in 87, and neutral in 6 cases. When, from the largeness of the dose or the condition of the patient, the salt acted as a purgative, it was usually carried off by the bowels, and did not communicate an alkaline quality to the urine. But, on the contrary, when it did not excite purging, it became absorbed, and rendered the urine alkaline. These opposite effects were probably referable to differences in the density of the saline solutions employed: those which were denser than the serum of the blood provoking purgation, while those which were less dense became absorbed (see p. 92).

Cherries, strawberries, and probably most sweet fruits, render the urine alkaline. They are enabled to do this in consequence of containing a vegetable alkaline salt, which, in traversing the system, becomes converted into a carbonate. Those fruits which contain only or chiefly free acid,—as currants and lemons,—do not render the urine alkaline.

In order to become converted into carbonates (or bicarbonates) the vegetable alkaline salts must undergo oxidation in the system, by which the vegetable acid is resolved into carbonic acid and water. Acetic acid ($C^4 H^3 O^3$) requires eight equivalents of oxygen; citric acid ($C^{12} H^5 O^{11}$), a tribasic acid, eighteen equivalents of oxygen; and tartaric acid ($C^8 H^4 O^{10}$), a bibasic acid, ten equivalents, to convert them respectively into carbonic acid and water.

The salts are employed therapeutically for various purposes, of which the following are the chief:—

1. As cooling or antiphlogistic cathartics or laxatives, in febrile or inflammatory complaints. They are also useful in other cases where a mild action on the gastro-intestinal mucous membrane is required, along with a gently resolvent effect on the system, as in liver complaints. The sulphates of soda, magnesia, and potash, the alkaline tartrates, and the phosphate of soda, are the salts in most frequent use as cathartics.

Alum acts as an astringent (see p. 158).

2. As diuretics in dropsies, and also in other complaints attended with deficient secretion of urine. The density of saline solutions given to act on the kidneys should be less than that of the serum of the blood (see p. 92). The salts in most frequent use as diuretics are nitrate of potash, and the alkaline acetates, citrates, and tartrates.

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[1] Wöhler states, that after the use of several drachms of these salts the urine effervesces, on the addition of an acid, like champagne.

3. In fevers, salines are in almost universal use. They are employed with the obvious effect of promoting the action of the secreting organs, and with the supposed effect of altering the crasis of the blood.

Dr. Stevens[1] explains the efficacy of salines in malignant fevers, by supposing that they restore to the blood the saline matter in which, in these cases, he declares this fluid to be deficient, as is evinced by the dark colour of the circulating fluid. To the saline impregnation he ascribes the vermilion-red colour, and some other properties of the blood, and he regards the black colour of this liquid as a certain proof of the loss or diminution of its saline ingredients.

4. In inflammation, the salines are used as antiphlogistics, liquefacients, and resolvents (see p. 175).

5. To restore the saline qualities of the blood in malignant cholera. In this disease the blood is remarkably black, incapable of coagulating, and contains more albumen and hæmatosin, but less water and saline parts, than natural; while the enormous discharges from the bowels consist of a weak solution of albumen containing the salts of the blood.[2] The obvious indications, therefore, in the treatment of this disease, are, to restore the water and saline matters to the blood. Hence originated what has been called the *saline treatment* of cholera. This, at first, consisted in the exhibition of certain alkaline salts by the mouth, and in the form of enemata. The following are formulæ which have been recommended:—

Take of Carbonate of soda	half a drachm.
Chloride of sodium	a scruple.
Chlorate of potash	seven grains.

Dissolve in half a tumblerful of water.

This to be repeated at intervals of from fifteen minutes to an hour, according to circumstances (Dr. Stevens, *op. cit.* p. 459).

Take of Phosphate soda	10 grains.
Chloride of sodium	10 grains.
Carbonate of soda	5 grains.
Sulphate of soda	10 grains.

Dissolve in six ounces of water.

The mixture to be repeated every second hour (Dr. O'Shaughnessy, *op. cit.* p. 54).

This plan, however, was followed by that of injecting saline solutions into the veins, which was, I believe, first practised by Dr. Latta.[3] The quantity of saline solution which has been in some cases injected is enormous, and almost incredible. In one case, "120 ounces were injected at once, and repeated to the amount of 330 ounces in twelve hours. In another, 376 ounces were thrown into the veins between Sunday at 11 o'clock, A.M. and Tuesday at 4, P.M.: that is, in the course of fifty-three hours, upwards of thirty-one pounds. The solution that was used consisted of two drachms of muriate and two scruples of carbonate of soda to sixty ounces of water. It was at the temperature of 108° or 110° F."[4] In another series of cases, 40 lbs. were injected in twenty hours: 132 ounces in the first two hours; 8 lbs. in half an hour![5] The *immediate* effects of these injections, in a large majority of cases, were most astonishing: restoration of pulse, improvement in the respiration, voice, and general appearance, return of consciousness, and a feeling of comfort. In many instances, however, these effects were only temporary, and were followed by collapse and death. In some, injurious consequences resulted, as phlebitis,[1] drowsiness,[2] &c. The reports as to the ultimate benefit of the saline treatment in cholera are so contradictory, that it is exceedingly difficult to offer to the student a correct and impartial estimate of its value. That it failed in a large proportion of cases after an extensive trial, and greatly disappointed some of its staunchest supporters, cannot be doubted.[3] Dr. Griffin[4] states, that all the published cases of injection which he can find recorded amount to 282, of which 221 died, while 61 only recovered: but he thinks that the average recoveries from collapse by this method of treatment "far exceeded the amount of any other treatment in the same disease, and under the same circumstances."

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[1] *Observations on the Healthy and Diseased Properties of the Blood*, p. 356, *et seq.* Lond. 1832.

[2] Dr. O'Shaughnessy, *Report on the Chemical Pathology of the Malignant Cholera*, 1832.

[3] *Lond. Med. Gaz.* vol. x. p. 257.

[4] *Ibid.*

[5] *Ibid.* vol. x. pp. 379-80.

6. As antilithics and lithontriptics. The acetates, citrates, and tartrates modify the composition of the urine, and communicate to it an alkaline quality (see p. 180). Hence they are used as antilithics or lithontriptics in the lithic acid diathesis (see *Lithontriptica*).

7. As resolvents, liquefacients, sorbefacients, and alteratives in glandular enlargements, and in chronic inflammation of a scrofulous or rheumatic character.

3. *Iodica et bromica. Iodine, bromine, and their compounds.*—This section includes the following substances:—

Iodinium.
Brominium.

Potassii iodidum.
Potassii bromidum.

The iodides and bromides of lead, iron, and mercury, may be conveniently referred to the sections including their metallic bases.

The chemical action on the animal tissues of iodine and bromine has been already noticed (see p. 93). The alkaline iodide and bromide act in an analogous manner to the other alkaline salts (see p. 178).

The iodica and bromica are absorbed and pass into the blood, in which fluid several of them have been detected (see p. 101). Some (*e. g.* iodine and bromine), if not all of them, enter the blood in a state of combination. From analogy rather than from observation, the iodica and bromica are supposed to lessen the amount of solid constituents (especially the fibrine and corpuscles), and to increase the proportion of water.[5] The augmented secretions, the thinness and wasting, and the disappearance of scrofulous and other swellings, observed under their use, evince their liquefacient and antiplastic operation. They are thrown out of the system by the excreting organs (see p. 102).

Iodine is an important topical agent, and as such has already been noticed (see pp. 158-9).

The iodica and bromica are used in medicine as alteratives, liquefacients, resolvents, and sorbefacients. They are useful in aiding the removal of some of the products of inflammation, such as serum, liquor sanguinis, and the healthier kind of fibrine and exudation corpuscles. They are chiefly serviceable in scrofulous, rheumatic, and syphilitic inflammations. They are not adapted for acute inflammation, but for inflammation of a chronic character. They are also serviceable in relieving certain non-malignant alterations of texture referable not to inflammation, but to perverted nutrition, and which are accompanied with increased deposit of solid matter,—such as induration with enlargement or swelling of organs, especially of the lymphatic glands, liver, and spleen. It is doubtful whether they have any influence over that kind of increased nutrition which is attended with hypertrophy.

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[1] *Lond. Med. Gaz.* vol. x. p. 453.

[2] *Ibid.* p. 447.

[3] *Ibid.* vol. x. p. 717.

[4] Dr. Griffin, *Recollections of Cholera*, in *Lond. Med. Gaz.* vol. xxii. p. 319.

[5] Simon's *Animal Chemistry*, vol. i. p. 307, English translation by Dr. Day.

4. *Sulphurosa. Sulphur, sulphuretted hydrogen, and the alkaline sulphurets.*—This section includes the following substances:—

Sulphur.
Acidum hydrosulphuricum.
Potassii sulphuretum.
Ammonii sulphuretum.
Aquæ sulphureæ seu hepaticæ.

These substances are referred to the *spanæmica* on account of their alterative, resolvent, and liquefacient properties, and their consequent analogy to the substances contained in the preceding sections. No analysis of the blood of animals under their influence has hitherto been effected.

By the inhalation of sulphuretted hydrogen gas (acidum hydrosulphuricum), or of the vapour of hydrosulphuret of ammonia (sulphuret of ammonium), as well as by the ingestion of the alkaline sulphurets, the blood assumes a dark colour,—an effect which, in the case of sulphuretted hydrogen, Liebig[1] ascribes to the action of this gas on the iron in the blood.

When the alkaline sulphurets are swallowed, a portion of them suffers decomposition by the acids of the stomach, and, in consequence, an evolution of sulphuretted hydrogen takes place. The undecomposed portion becomes absorbed, and is eliminated by the kidneys; but, during its passage through the system, some of it undergoes oxidation, and is converted into sulphate.

Sulphur taken into the stomach is, for the most part, evacuated by the bowels; but a portion becomes absorbed, and may be detected in the secretions: in the urine it is found as sulphate and sulphuret.[2] It is probable, therefore, that, by the mutual action of sulphur and the soda of the bile, sulphuret of sodium and sulphate of soda are formed, and that these are subsequently absorbed.

Sulphuretted hydrogen gas and the vapour of sulphuret of ammonium, when inhaled, act as narcotic or narcotico-irritant poisons; and the alkaline sulphurets, if swallowed in sufficient quantities, operate as narcotico-irritants.

The *sulphurosa*, when employed medicinally, promote the action of the secreting organs; their influence being directed principally to the skin and mucous membranes. They have been supposed to possess a specific stimulant influence over the pelvic venous system. Their influence over the skin is undoubted; and their efficacy in chronic cutaneous diseases has long been established. In these maladies, sulphur and the sulphurous waters are employed internally; while, as external remedies, solutions of the alkaline sulphurets and the sulphurous waters are used. On account of their influence over the mucous membranes, the sulphurosa have been employed in chronic bronchial affections: but, in this country, they are rarely administered in these cases.

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[1] *Animal Chemistry*, p. 274, Lond. 1842.

[2] Wöhler (Tiedemann's *Zeitschrift*, Bd. i. S. 131) found in the urine of a dog, to whom he had given a drachm of flowers of sulphur, an unusual quantity of sulphate, and likewise some sulphuret; for sulphuretted hydrogen was evolved on the addition of hydrochloric acid. More recently, MM. Laveran and Millon (*Annuaire de Chimie*, 1845, p. 588) state, as the result of their experimental observations, that sulphur is neither oxidized, nor otherwise modified, and that it does not become absorbed. But their negative results cannot disprove the positive ones of so accurate an observer as Wöhler. Moreover, their statements are in opposition to the common observation of the odour of sulphuretted hydrogen evolved by the breath and secretions of persons who have been using sulphur internally.—Unoxidised sulphur has been detected in healthy urine by Dr. Ronalds (*Phil. Trans.* 1846).

In hemorrhoidal affections and uterine obstructions (chlorosis and amenorrhœa), sulphur and the sulphureous waters are frequently resorted to, on account of their supposed stimulant influence over the pelvic venous system.

Lastly, solutions of the alkaline sulphurets are used as baths where the skin is impregnated with lead (see p. 161).

5. *Mercurialia et antimonialia. Mercurials and antimonials.*—This section includes the following substances:—

Mercurialia.

Hydrargyrum.
Hydrargyri oxydum.
Hydrargyri binoxydum.
Hydrargyri chloridum (*calomel*).
Hydrargyri bichloridum.
Hydrargyri iodidum.
Hydrargyri biniodidum.

Antimonialia.

Antimonii sesquioxydum.
Antimonii oxysulphuretum.
Pulvis antimonii compositus (*Ph. Lond.*)
Potassæ antimonio-tartras (*Ph. Lond.*)

The topical action of these agents is not uniform. Mercury, so long as it retains its metallic or reguline character, is apparently inert. All the others probably exercise a local chemical influence; and of these, bichloride of mercury is the most active (see p. 94). Chloride of mercury (calomel), when swallowed, suffers some chemical change, and yields a soluble mercurial compound (see p. 89).

The mercurials and antimonials become absorbed into the blood, and are afterwards eliminated by the excretory organs. Mercury and antimony have been detected in the blood, solids, and urine of patients to whom preparations of these metals had been administered (see pp. 101 and 102). Mercury has also been recognised in other secretions (see p. 102).

The mercurials and antimonials promote secretion and exhalation generally, though they do not equally affect all the secreting and exhaling organs. The specific effect of mercurials on the mouth (ptyalism), and of antimonials on the skin (diaphoresis), are well known.

The effects produced on the blood by the protracted use of these agents have not been chemically investigated. The older writers[1] state, that mercury produces a watery and dissolved condition of the blood; and the same kind of opinion, expressed in a different form of language, is held by modern writers.[2] I am unacquainted with any chemical observations as to the state of the blood after the protracted use of antimonials; but, from analogy, it is inferred to be similar to that caused by mercurials.

In the treatment of acute inflammation with fever, mercurials and antimonials constitute the most important of our medicinal remedies. Antimonials are principally adapted for relieving the febrile symptoms, reducing the force of the heart's action, moderating the heat of skin, and promoting sweating: in inflammation, therefore, their beneficial effects are best seen in the early stages of the disease. Over the effused products of inflammation they have little influence. Mercurials, on the other hand, are useful in inflammation principally by their influence over the products of this malady: they both check effusion and promote the removal of the lymph already deposited. Antimonials, therefore, are said to be useful in inflammation and fever by their contra-stimulant (see p. 96), sedative, and sudorific influence; mercurials, by their alterative, sorbefacient, and resolvent effects. Antimonials are most useful in continued fever, rheumatic inflammation, and bronchitis; mercurials, on the other hand, are more fitted for inflammations having a tendency to terminate in effusions of coagulable lymph,—as iritis, inflammation of the serous membranes, and croup; in syphilitic inflammation; and in indurations and enlargements of organs.

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[1] "A long and large use of mercury will turn the whole mass of blood into a mere watery colluvies" (Huxham, *Essay on Fevers*, p. 46, 3d Lond. edit. 1757).

[2] See *post*, art. *Hydrargyrum*. Also Dr. Farre, in Ferguson's *Essays on the Diseases of Women*, part i. p. 216; Dietrich, *Die Merkurial-Krankheit*, p. 80, Leipzig, 1837; and Simon, *Animal Chemistry*, vol. i. p. 307, English translation by Dr. Day. Dr. Farre states, that a course of mercury diminishes the number of blood-corpuscles; and he says that he gave mercury to a full plethoric woman, and "in six weeks blanched her as white as a lily."

Both antimonials and mercurials are used as evacuants: the former, as emetics, sudorifics, and expectorants; the latter, as purgatives and sialogogues.

SUB-ORDER γ. SPANÆMICA ANTISPASMODICA.—Antispasmodic spanæmics. This sub-order includes the following substances:—

Acidum arseniosum.
Cupri sulphas.
Cuprum ammoniatum.
Argenti nitras.
Bismuthi trisnitras.
Zinci oxydum.
Zinci sulphas.

All these agents exercise a topical chemical influence over the organised tissues (see pp. 94 and 164), in virtue of which they are used as caustics (see p. 157). Swallowed in sufficient doses, they act as irritant poisons.

When taken into the stomach, they suffer, in this organ or in the intestinal canal, more or less chemical change (see p. 89), and, in this altered state, become absorbed. The metallic bases of the substances comprising this sub-order have been detected in the blood, and most of them in the solids and urine (see pp. 101 and 102).

All these agents, by long-continued use, impoverish the blood,—that is, act as spanæmics; but the precise changes which they effect have not been investigated.

They exercise a well-marked influence over the nervous system. This is shown by the cramps, convulsions, paralysis, and even narcotism, which they induce when swallowed in poisonous doses; and by their efficacy in the treatment of some morbid conditions of this system,—for example, chorea and hysteria, whence they have been denominated *antispasmodics*. Thus chorea is cured by arsenic; while epilepsy is frequently benefited or even cured by arsenic, copper, or silver.

These agents are also remarkable for their curative influence in agues and other periodical diseases, in consequence of which they have been denominated *tonics*.

SUB-ORDER δ. SPANÆMICA SATURNINA.—The saturnine or plumbeous spanæmics. The following are the preparations of lead commonly used as medicines:—

Plumbi oxydum (*lithargyrum*).
Plumbi iodidum.
Plumbi carbonas.
Plumbi acetas.
Plumbi diacetas.

All these agents exercise a greater or less chemical influence over the organised tissues and fluids; by which, changes are effected both in the preparations themselves and in the animal tissues and fluids (see pp. 89 and 94). Mialhe[1] asserts, that all the salts of lead, even the sulphate, are partially or wholly decomposed and converted into chlorides by the alkaline chlorides contained in the animal fluids; and he, therefore, doubts the specific antidotal property of sulphuric acid. Dr. C. G. Mitscherlich's observations on the action of acetate of lead on animal matter will be noticed hereafter (see *Plumbi acetas*).

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[1] *Mémoire sur les émanations du Plomb et l'Absorption des Médicaments*, Paris 1844 (noticed in the *Supplément au Dictionnaire Universal de Matière Médicale*, p. 570, Paris, 1846).

The compounds of lead, formed by the action of the tissues and fluids of the alimentary canal on the preparations of lead, are some soluble, others insoluble: the former are absorbed, the latter rejected.[1]

The absorption of lead is proved by its subsequent detection in the blood,[2] solids, and excretions (see pp. 101 and 102). Dr. Todd,[3] in a case of chronic saturnine poisoning, found lead "in great quantity in the brain, and in the lung this metal was found in still greater proportion;" and more recently, Dr. Inmann[4] detected lead in the cerebellum of a painter.

In saturnine cachexy, Andral and Gavarret[5] invariably found a deficiency of blood-corpuscles. The following table shows the mean composition, according to these authors, of healthy blood and of the blood of a patient where this cachexy constituted the sole malady.

	Healthy blood.	*Blood in saturnine cachexy.*
Fibrine	3	2·8
Blood-corpuscles	127	83·8
Solid residue of the serum	80	78·1
Water	790	835·3
	1000	1000·0

The blood appears also to have suffered an alteration in some other respects; for the serum is of a dirty or earthy-yellow hue. The skin, the conjunctival membrane, and the viscera, have the same tint, apparently in consequence of being impregnated with blood altered in its colour. This, then, is the source of the so-called *icterus saturninus*.

Lead is eliminated from the system by the urine (see p. 102), by the skin,[6] and by the milk (see p. 102).

When the preparations of lead are administered for therapeutical purposes, their primary effects, and for which they are usually employed, are a diminution in the volume and frequency of the pulse, and in the activity of the functions of secretion. These are the general though not universal effects. Hence the preparations of lead are described as being sedative and astringent—terms which imperfectly express the real character of the effect. When the system is under the influence of this metal, the pulse is usually smaller and sometimes slower than natural. Tanquerel des Planches has seen it reduced to 55, 50, 45, and even to 40 beats per minute. The secretions of the mucous membranes and their glands are diminished; the mouth and nose become drier; the bowels constipated; the stools harder and of a paler yellow colour; and the urine is lessened in quantity. These effects, however, are by no means constant or uniform.

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[1] In patients affected with saturnine colic, lead has been found in the fæcal matters by Mérat, by Chatain (*Supplément*, supra cit. p. 571), and by Duvergie (Tanquerel des Planches, *Traité des Maladies de Plomb*, t. i. p. 325).

[2] Cozzi (*Lancet*, May 11, 1844, p. 227) detected a salt and an oxide of lead in the blood of a patient labouring under lead colic. They were in combination neither with the hæmatosin nor the fibrine, but with the albumen.

[3] *Practical Remarks on Gout, Rheumatic Fever, and Chronic Rheumatism of the Joints*, pp. 23 and 24, Lond. 1843.

[4] *London Medical Gazette*, August 28, 1846, p. 389.

[5] *Ann. de Chimie et de Physiq.* t. lxxv. pp. 309-10, November, 1840.

[6] The elimination of lead by the skin is shown by the repeated re-formation of sulphuret of lead during the time the patients are using the sulphurated baths (Mialhe, op. cit.; Taylor, *On Poisons*, p. 449).

When the system is impregnated with lead, the presence of this metal may be manifested by a specific action on the solids and liquids of the organism before the development of the saturnine diseases, and which is called by Tanquerel des Planches *primitive saturnine intoxication.* The characteristic phenomena of this are the following:—

1st. Saturnine coloration of the gums, of the buccal mucous membrane, and of the teeth. A narrow leaden-blue or slate-blue line,[1] from one-twentieth to one-sixth of an inch in breadth, is formed on the margins of the gums nearest to two or more teeth (usually the incisors) of either jaw. The rest of the gums are of a bluish-red tint. I have seen the mucous membrane lining the lips and part of the cheek stained blue, like the edges of the gums. The teeth, especially at their lower part or neck, are frequently more or less deeply stained brown. The blue coloration depends on the presence of sulphuret of lead.[2]

Dr. Chowne[3] denies that the presence or absence of the blue line on the margin of the gums has any certain connexion with the administration or non-administration of lead. On this point I may observe, that I have satisfied myself that in several cases in which the blue line on the gums, and even the slate blue staining of the lips, were observed, no evidence of poisoning by lead could be obtained. In most of the cases there were no constitutional symptoms of lead poisoning. In one case (that of a woman), an out-patient of the London Hospital, who applied for relief in consequence of suffering with dyspepsia, the blue line on the gums, and the blue staining of the lips, were more marked than in any cases of positive lead-poisoning which I have seen. I analysed the water she used, and the beer and gin which she drank, without gaining the least evidence of the presence of lead. In another case (a private patient, labouring under organic disease of the brain), I detected traces of lead in the bottled soda-water of which she had partaken; but I am persuaded that this was an accidental circumstance. On the other hand, in every case of lead-poisoning which I have met with, and they are not a few, and in several cases in which sugar of lead, in large doses, had been taken medicinally for many days continuously, I have observed the blue line. It is stated[4] that a similar blue mark has been noticed in poisoning by mercurial compounds. In many cases of mercurial ptyalism, however, I have in vain looked for it.

To what is the formation of the blue sulphuret of lead owing? Tanquerel des Planches ascribes it to the action of sulphuretted hydrogen (evolved by the decomposing fragments of food lodged between the teeth) on the saturnine particles which pass through the mouths of those who respire or swallow lead. May it not be due to the action of sulphuretted hydrogen on lead contained in the saliva and buccal mucus?

2d. Saturnine taste and breath. Workmen who are under the influence of lead complain of a peculiar taste; and their breath has a peculiar odour (called by Tanquerel des Planches the *saturnine breath*).

3d. Saturnine icterus. This has been already noticed.

4th. Saturnine emaciation. This usually accompanies or follows the saturnine icterus. Although it is general, it is most evident in the face, which becomes wrinkled, and gives to the individual a more aged and care-worn appearance.

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[1] The presence of this line is fully described by Tanquerel des Planches, in his *Traité des Maladies de Plomb*, vol. i. p. 3, Paris, 1839; and by Dr. Burton, in a paper read to the Royal Medical and Chirurgical Society, Jan. 14, 1840 (*Medico-Chirurgical Transactions*, vol. xx. Lond. 1840.)

[2] By the action of oxygenated water, the blue substance is converted into the white sulphate of lead. By digesting the gums and teeth of a colour-grinder, who died from the effects of lead, with a solution of sulphuretted hydrogen for twenty-four hours, those parts of the gums which had not before presented the blue mark acquired a deep blue tint (Tanquerel des Planches, op. supra cit. vol. i. p. 6).

[3] *Lancet*, Oct. 26, 1844, p. 145.

[4] Taylor, *On Poisons*, pp. 384 and 488.

5th. State of the circulation. This has been before alluded to. The pulse is usually smaller, sometimes slower, and occasionally irregular.

These phenomena of primitive saturnine poisoning form, according to Tanquerel des Planches, the prodromi or forerunners of the saturnine maladies.

Poisoning by lead presents the four following distinct forms of disease, each of which may exist alone, or may be complicated with one or more of the others, or may follow the others, without, however, having any definite order or succession.

1. Lead colic; *colica saturnina; c. pictorum; c. pictonum.* This is by far the most frequent of the diseases.

2. Arthralgia; *arthralgia saturnina; rheumatismus metallicus* of Sauvages. In frequency, this is next to colic.

3. Paralysis. This may affect either the motility or the sensation of parts: in the former case it is called paralysis of motion, or simply saturnine paralysis (*paralysis saturnina*); in the latter case it is termed *anæsthesia saturnina.* Paralysis occurs next in frequency to arthralgia.

4. Disease of the encephalon; *encephalopathia saturnina.* This, which is the least frequent of all the forms of saturnine poisoning, is manifested by different morbid phenomena; viz. by delirium, by coma, or by convulsions, with or without the loss of one or more of the senses.

The objects for which the preparations of lead are employed in medicine are few. We use them chiefly as sedatives, as astringents, and desiccants. The diseases, also, for which we resort to them are few: they are chiefly hemorrhages and fluxes. We apply them topically when we can get with safety at the affected part; and, on other occasions, we administer them internally. In the latter cases, we almost exclusively employ the acetate. Although the preparations of lead are more serviceable in asthenic cases, they may be administered with safety in sthenia, for which their sedative influence adapts them.

In hemorrhages (as from the lungs, uterus, &c.) the acetate of lead is serviceable both by its sedative and astringent influence: by the former, it is useful in reducing the force and frequency of the circulation; by the latter, it serves to lessen the volume of the bleeding vessels.

In fluxes, the preparations of lead are chiefly beneficial by their astringent influence: they are more serviceable when they can be applied directly to the affected parts. We use them in bronchial, gastric, intestinal, and vaginal fluxes: in the three former cases the acetate is employed, generally in combination with opium. In leucorrhœa, acetate and diacetate of lead are used as topical applications. In ophthalmic practice, the employment of the acetates of lead is objectionable on account of the opaque and generally indelible depositions their solutions leave on abraded or ulcerated spots of the conjunctiva or cornea.

Lead-washes are useful as cooling and sedative applications in superficial inflammation, in contusions, fractures, excoriations, &c. In profuse discharges from the skin (as in eczema and impetigo), the preparations of lead are useful as desiccants.

ORDER 4. HÆMATINICA (αἱματινικά, from *hæmatin*, αἱμάτινα, *the red colouring matter of the blood*). *Tonica analeptica.*—Medicines which augment the number of blood-corpuscles or the amount of hæmatin in the blood. This order is exclusively composed of iron and its compounds : *ferruginea ; martialia ; chalybeates.*

The following is a list of the more frequently employed substances composing this order :—

Ferrum.
Ferri oxydum nigrum.
Ferri sesquioxydum.
Ferri sesquichloridum.
Ferri iodidum.
Ferri carbonas.
Ferri sulphas.
Ferri ammonio-citras.
Ferri ammonio-tartras.
Ferri potassio-tartras.
Aquæ ferruginosæ.
  α. carbonicæ.
  β. vitriolicæ.

The topical action of these chalybeates is very unequal. Iron, so long as it retains its metallic state, acts mechanically only. The oxides of iron act very mildly as topical agents. The sesquichloride and sulphate, however, are caustics and astringents.

The salts of iron produce a black stain when applied to the tongue, and communicate a dark colour to the stools. The latter effect was formerly ascribed to the production of the black oxide of iron ;[1] but, according to Kersten,[2] whose opinion has been adopted by Berzelius, it depends on the formation of sulphuret of iron by the action of an alkaline sulphuret on the ferruginous salt.[3]

The preparations of iron, when taken into the stomach, are partly absorbed, partly evacuated, sometimes more or less altered, with the stools. The red colour which the sesquioxide of iron communicates to the stools of children, and the black colour of the stools after the employment of the salts of iron, are proofs of the presence of iron in the alvine discharges. The detection of iron in the blood, urine, and milk (see *ante*, pp. 101 and 102), after the use of chalybeates, demonstrates the absorption of iron.

The constitutional effects of iron are best observed in anæmia. If, in this condition of system, chalybeates be administered, the appetite increases, digestion is promoted, the pulse becomes fuller and stronger, the skin assumes its natural tint, the lips and cheeks become more florid, the temperature of the body is increased, the œdema disappears, and the muscular strength is greatly augmented. These effects are mainly due to the alteration in the composition of the blood. This is shewn by the healthy vermilion tint which the patient acquires, as well as by the chemical analysis of the blood.

The remarkable change effected in the composition of the blood by the use of iron is well shewn in the following table :—

COMPOSITION OF THE BLOOD OF A CHLOROTIC GIRL.

	Before the use of iron.	*After the use of iron.*
Water	871·500	806·500
Solid constituents	128·500	193·500
Fibrin	2·080	1·200
Fat	2·530	2·299
Albumen	79·820	81·230
Globulin	30·860	90·810
Hæmatin	1·431	4·598
Extractive matters and salts	11·000	9·580
Colouring matter contained in the hæmatoglobulin	4·4$\frac{0}{0}$	4·8$\frac{0}{0}$

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[1] Guersent, *Dict. de Médecine*, art. *Fer*, t. viii. p. 529, 1823.—Barruel (Trousseau and Pidoux, *Traité de Thérapeut.* t. ii. 1e part, p. 186,) ascribes the dark colour to the union of the oxide of iron with gallic or tannic acid contained in the food.

[2] Simon's *Animal Chemistry*, translated by Dr. Day, Vol. ii. pp. 389—390.

[3] The blackening may be produced by the action on the ferruginous salt either of hydrosulphate

The girl took two ounces of the tincture of iron and sixty-four grains of metallic iron in seven weeks. "This change in the composition of the blood," observes Simon,[1] from whom the case is quoted, "is truly surprising, and affords an excellent illustration of the wonderful effects of certain remedies. The amount of solid constituents is increased by nearly one-half, and the increase of the hæmatoglobulin is likewise extraordinary. In this, as well as in Andral and Gavarret's observations, the quantity of the fibrin is diminished: the proportion of the hæmatin to the globulin is however slightly, although not materially, increased. The changes in the condition of the patient kept pace with those of the blood. Before, she was pale, and her lips colourless; now, she presented a really blooming appearance. Andral and Gavarret have arrived at perfectly analogous results."

The menstrual function is frequently either entirely suspended in anæmia, or the discharge is small in quantity, and of a pale watery character. The restoration of the function and the improvement in the quality of the evacuation, effected by the use of iron, are referable to the beneficial change produced in the quality of the blood.

The efficacy of purgatives in promoting the effect of the ferruginous compounds in anæmia has been ingeniously explained by Dr. G. O. Rees.[2] By removing water from the blood, they increase the specific gravity of the plasma. This, then, by an endosmotic action, deprives the blood-corpuscles of their dilute watery hæmatin, which is replaced by the more dense liquor sanguinis. The corpuscles, when thus supplied with a liquor denser than the chyle, are in a condition to absorb, by an endosmotic action, the ferriferous chyle. After the long-continued use of the ferruginous compounds, we frequently find excitement of the vascular system (particularly of the brain): thus we have throbbing of the cerebral vessels, and sometimes pain in the head, a febrile condition of system, with a tendency to hemorrhage.

Mr. Carmichael[3] considers the sanguine temperament (marked by a high complexion, celerity of thought, remarkable irritability of fibre, and a quick pulse,) as depending on an excess of iron in the system; whereas the leucophlegmatic, or relaxed, temperament (characterized by a pale bloated countenance, dull eyes, mind heavy and slow in receiving and forming ideas, little irritability of fibre, and pulse small and feeble,) as depending on a deficiency of iron.

In the treatment of anæmia, iron acts, in part, as an aliment. It supplies to the blood-corpuscles an ingredient in which they are deficient, and it may, therefore, be said to serve as nourishment for them.

The condition in which the iron exists in the hæmatin is still a *questio vexata;* and, therefore, the most appropriate ferruginous compound for the treatment of anæmia must, for the present, remain doubtful. Experience,

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of ammonia (sulphuret of ammonium), which frequently occurs in the intestinal canal, or of the sulphuret of potassium or of sodium (formed by the decomposition of the corresponding sulphate). Sulphuret of iron sometimes appears as a black or blackish-blue pigment on the walls of unhealthy fetid abscesses, and as a slate-grey pigment on the surface of the liver, spleen, and intestinal canal, when no ferruginous compounds have been swallowed. In such cases, it is formed by the action of hydrosulphuret of ammonia on the blood-pigment (see Vogel's *Pathological Anatomy*, translated by Dr. Day, pp. 194—196, and 396, Lond. 1847).

[1] *Animal Chemistry*, translated by Dr. Day, vol. i. pp. 310—313, 1845.

[2] *London Medical Gazette*, April 4, 1845, pp. 758—59, and 853—4.

[3] *Essay on the Effects of Carbonate of Iron on Cancer*, Dubl. 1806, p. 396.

however, has fully proved that this condition of system may be cured both by metallic iron and by the ferruginous compounds; both by peroxide and persalts, and by protoxide and protosalts; both by insoluble and by soluble ferruginous preparations; and both by compounds which contain iron in the basic part, and by those which contain it in the acid part.

But, though all these substances are capable of acting as hæmatinics and of curing anæmia, they are not all equally eligible or efficacious. Some of them, in fact, do not possess any immediate or direct hæmatinic power,—as metallic iron and the insoluble ferruginous compounds; for metallic iron acquires medicinal activity only by decomposing water in the stomach, and combining with oxygen to form the protoxide of iron, which dissolves in the acid contents of the stomach, and in this way becomes absorbable, while hydrogen gas is evolved; and the insoluble ferruginous compounds, not being absorbable, cannot act on the general system; but, by the change effected in them by the acid liquors in the gastro-intestinal canal, they give rise to the formation of soluble compounds, which are absorbed; and in this way the insoluble ferruginous compounds indirectly or mediately act as hæmatinics. But, as they depend for their activity on the acidity of the gastro-intestinal juices, which is limited and variable, it is obvious that their operation is slow, and cannot be uniform.

All the soluble ferruginous preparations which contain iron in the basic part,—such as the iodide, chloride, and sulphate,—possess medicinal activity, and act as hæmatinics. The chloride and sulphate are also powerful astringents, and, when swallowed in sufficient quantity, act as caustic and irritant poisons.

But of the soluble compounds containing iron in the acid part some are valuable as hæmatinics, such as the ammonio-citrate of iron and tartarized iron;[1] while others, such as ferrocyanide and ferridcyanide of potassium,[2] are useless as hæmatinics, and are not applicable, therefore, for the cure of anæmia.

By a careful attention to the known physiological effects of the ferruginous compounds, the indications and contra-indications for their use may be, in a great measure, ascertained.

The general indications for their use are debility, feebleness and inertia of the different organs of the body, atony (marked by a soft, lax, or flabby condition of the solids), and defect of the red corpuscles of the blood,—as where there is a general deficiency of this fluid (*anæmia; oligæmia*), or a watery condition of it (*hydræmia; serous crasis; leucophlegmatic temperament*).

The contra-indications are the reverse of these: great strength and activity of organs, excessive tonicity (characterised by a firm and tense condition of the solids), and redundancy of the red corpuscles of the blood,—as in general excess of the blood (*plethora*), in fever, in acute inflammation, and in the sanguine temperament. To these may be added, congestion, or a tendency thereto, of important organs, especially of the brain and lungs, and intestinal irritation.

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[1] These compounds are probably decomposed by the acids of the gastric juice. Mialhe (*Traité de l'Art de Formules*, p. 165, 1845) assumes, that the vegetable acids of these salts, like those of the alkaline salts (see *ante*, p. 180), undergo oxidation in the system, and are converted into carbonates. But Wöhler states, that tartarized nickel (tartrate of nickel and potash), a salt analogous in composition to tartarized iron, is eliminated in the urine unaltered (see *ante*, p. 101).

[2] Ferrocyanide of potassium is eliminated in the urine unchanged, while the ferridcyanide is converted into the ferrocyanide (see *ante*, pp. 101 and 102). Mialhe asks why these cyanides of potassium and iron pass in the urine, "as Wöhler has incontestibly shown;" and then replies, because they "are not decomposed by the alkalies of the blood." But these compounds are not both eliminated in the urine: Wöhler distinctly states, that one only passes unchanged, as I have above stated.—It deserves notice, that Faraday (*Phil. Trans.* for 1846, p. 43) found that "every salt and compound containing iron in the basic part was magnetic," and pointed axially; whereas ferrocyanide and ferridcyanide of potassium pointed equatorially (see *ante* p. 57), and were, therefore, diamagnetic.

The following are some of the more important diseases in which chalybeates prove serviceable:—

1. In maladies attended with defect of the red corpuscles of the blood; as in anæmia, with or without irregularity of the uterine functions (chlorosis, amenorrhœa, dysmenorrhœa, and menorrhagia), and whether occurring spontaneously and without any obvious cause, or resulting from profuse discharges (hemorrhages, fluxes, as leucorrhœa, &c.), from food defective in either quantity or quality, and from deficiency of light and pure air. In these cases, the use of iron, conjoined with sufficient nourishing food, pure air, abundance of light, and, when necessary, the employment of purgatives (see p. 190), proves curative. But, when the anæmia or hydræmia is dependent on organic diseases,—as cancer, granular degeneration of the kidney, or morbus cordis,—the use of iron can at best be palliative only.

In what way does iron relieve anæmia? Is it merely by supplying the ingredient in which the blood is deficient? I think not. Anæmia frequently occurs without any obvious cause; when there has been no deficiency of food, air, and light, and no profuse discharges. In such cases the disease cannot be ascribed to want of iron in the system,[1] but to some defect in the sanguification process: the iron which is taken in with the food has not been properly applied in the manufacture of hæmatin or red blood-corpuscles. In such cases the chalybeate medicine relieves the anæmia by correcting the defect in the blood-making process, the seat and nature of which is at present unknown.

2. In some chronic affections of the nervous system great benefit is obtained by the use of iron. Chorea, in a large number of cases, may be relieved, and oftentimes cured, by chalybeates; though, in general, I consider them inferior to arsenic, which usually cures chorea much more speedily and certainly than they do. Cases, however, sometimes occur in which the chalybeates are preferable; as where anæmia or partial paralysis coexists. When anæmia is present, iron is obviously indicated, and when paralysis accompanies the chorea, I regard arsenic as hazardous. Epilepsy and hysteria are other nervous affections which are sometimes benefited by a course of iron, especially when they are attended with anæmia or uterine obstructions. Of the efficacy of iron in the shaking palsy caused by the vapour of mercury I have had no experience.

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[1] The following is an illustrative case:—A girl, of about fifteen years of age, suffering under spasmodic torticollis, for which various modes of treatment had been unavailingly employed, applied at the London Hospital as an out-patient, and was placed under my care. I prescribed iron thrice daily. Under this plan she improved, though very slowly; and the use of the iron was steadily persevered in. At the end of nine months, during the whole of which time she was taking iron, she became anæmic. Her face and lips were completely blanched, and she had the other usual characteristics of a patient suffering with anæmia. In this case there could not have been any deficiency of iron. I made no alteration in the treatment, and in the course of a few weeks all the anæmic symptoms subsided, and the girl resumed her usual appearance.

3. In diseases of the spleen the ferruginous compounds are occasionally found useful. "I regard iron as a specific," says Cruveilhier,[1] "in hypertrophy of the spleen, or chronic splenitis; whether primitive or consecutive to intermittent fevers." After noticing the symptoms attending this condition (such as paleness of the lips, &c. great lassitude, abdominal and cephalic pulsations, brought on by the slightest exertion, pain at the left side, disordered state of the digestive organs, accelerated pulse, and heart easily excited), he goes on to remark, "By the aid of iron I have obtained the complete resolution of enlargements of the spleen, which have occupied half, or even two-thirds, of the abdomen."

Is not iron useful in these cases by removing the coexistent anæmia? In disease of the spleen, accompanied with enlargement of this organ, but unattended by anæmia, I have found it fail to give relief.

It deserves to be noticed that in animals to whom sulphate of iron had been given, Weinhold[2] found the spleen smaller and firmer than usual.

In hypertrophy of the liver iron has not been found as beneficial as in hypertrophy of the spleen.

4. Some years ago the preparations of iron were strongly recommended in cancer by Mr. Carmichael.[3] He employed (externally and internally) various ferruginous compounds—namely, the ferrotartrate of potash, the sesquioxide of iron, and the phosphates of iron. Whatever hopes may have at one time been entertained of these remedies as curative agents in this most intractable disease, they no longer exist. That these medicines are occasionally useful as palliatives by relieving the anæmia and improving the general health must be admitted; but they have no curative powers.

Dr. Walsh[4] considers the iodide of iron as specially appropriate in cases of cancer attended with anæmia.

5. In some intermitting diseases—namely, ague,[5] asthma, and tic douloureux—the ferruginous preparations have gained considerable repute. In the first of these maladies their use has of late years been almost wholly superseded by sulphate of quinine and arsenic. In asthma, Dr. Bree,[6] who was himself a sufferer from the disease, regards iron as preferable to all other remedies. However, the experience of others has not confirmed his favourable opinion of it. The sesquioxide of iron has latterly been extensively employed, at the recommendation of Mr. B. Hutchinson,[7] in tic douloureux, and with variable success; in some cases acting in a most extraordinarily beneficial manner, in others being of no avail.

6. As astringents the sesquichloride and sulphate are used both as internal and topical agents. In mucous discharges from the genital organs, as gleet and leucorrhœa, the internal employment of the tincture of the sesquichloride of iron, sometimes conjoined with the tincture of cantharides, has been found highly useful. In spermatorrhœa, also, iron sometimes proves beneficial both by its astringent and by its tonic properties. In hæmorrhage from the stomach,

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[1] *Dict. de Médecine et de Chirurgie pratiques*, t. viii. p. 62.

[2] *Versuch über d. Leben*, quoted by Richter, *Ausführliche Arzneimittellehre*, Bd. v. p. 55.

[3] *Essay on the Effects of Carbonate of Iron in Cancer*, Dublin, 1806, p. 396.

[4] *The Nature and Treatment of Cancer*, p. 197, Lond. 1846

[5] Marc, in Sedillot's *Journal Général de Médecine*, t. xxxiv. and xxxix.

[6] *A Practical Inquiry on Disordered Respiration, distinguishing Convulsive Asthma, its Specific Causes*, &c. Birmingham, 1797.

[7] *Cases of Tic Douloureux successfully treated.* 1820.

the tincture of sesquichloride of iron serves the double purpose of a styptic and hæmatinic. Solutions of the sulphate and sesquichloride of iron have been employed as injections in discharges from the urethra and vagina; and the tincture of the sesquichloride is occasionally applied as a styptic or to repress the growth of spongy granulations. Lastly, Mr. Vincent[1] states that he has found great advantage from the employment of sulphate of iron (in the proportion of a grain of the salt to an ounce of water) in prolapsus ani. The patients should be kept in bed, and after the bowel has been cleansed out, a small quantity of the injection should be daily thrown up and retained.

7. In scrofula and rickets the long-continued use of ferruginous compounds, in some cases combined with alkalies or iodine, has appeared to me on many occasions to be highly beneficial. In these cases iron proves most serviceable where there is a manifest tendency to anæmia, with a pale flabby condition of the solids.

γ. Medicines acting Dynamically on the Blood.

As the living tissues may have their vital properties modified, independently of obvious physical and chemical agencies, by substances which are said to act dynamically (see p. 88), so it may be supposed that the living blood is liable to be affected in a similar way.

The agents which we might expect to act thus on the blood are the vegetable acrids and the substances commonly termed narcotics; for these bodies powerfully affect the vital properties of animals, without, for the most part, exercising any marked physical or chemical influence over the constituents of the living body.

The corpuscles and the fibrine are the organic elements of the blood, in the changes of which we might expect to procure some evidence of the dynamical action above alluded to. Hitherto, however, no conclusive proofs of the existence of this action have been obtained. The changes in the condition of the corpuscles which Schultz regards as vital, are, as I have before stated (see p. 108), clearly physical. The acceleration, retardation, or prevention of the coagulation of the blood, effected by various agents, may be due to physical or chemical as well as to vital changes.[2] Nor can we adduce alterations in the consistency of the plasma as evidence of the dynamical action producing them. In fine, however strong and well-grounded may be our belief in the dynamical action of medicinal and poisonous agents on the blood, conclusive evidence thereof is still wanting.[3]

Class V. *Pneumatica.* Medicines acting on the Respiratory Organs.

Medicines which act as therapeutical agents, by their influence over the functions of respiration and calorification, may be termed *pneumatica*, (πνευματικά; from πνέω, *I breathe*).

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[1] *Observations on some of the Parts of Surgical Practice*, Lond. 1847.

[2] "Mr. Hunter, conceiving coagulation to be an act of life, maintained that the blood coagulates by virtue of its living principle. If we admit this hypothesis, we must also admit that we can pickle the life; that it is preserved after repeated freezing and thawing; and, as Dr. Davy remarks, that the blood may remain alive many hours after the death of the body, when the muscular fibre has lost its irritability, the limbs have stiffened, and even partial decomposition has begun."—(*The Works of William Hewson*, F.R.S. edited by G. Gulliver, F.R.S., foot-note, p. 21, Lond. 1846.)

[3] Dr. C. B. Williams (*Principles of Medicine*, pp. 374 and 385) admits *necræmia* (νεκρὸs *dead*, and αἷμα *blood*), or death beginning with the blood, as one mode of death. The causes of this are poisons.

Some of them modify the respiratory movements by their influence over the muscles of respiration; some modify the condition of the aërian mucous membrane; some diminish the want of breath; while others influence the function of calorification.

1. *Pneumatica affecting the muscles of respiration.*[1]—These are agents which operate directly on the nervous system and indirectly on the muscles of respiration (see *Class* VI. *Neurotica*).

The efficacy of certain narcotics (*e. g.* stramonium and belladonna) in relieving a paroxysm of spasmodic asthma, may be ascribed to their power of allaying spasm of the muscular fibres of the bronchial tubes. Dr. C. J. B. Williams found that several substances destroyed the contractility of these fibres. "Extracts of stramonium and belladonna produced this effect most completely. Strychnia, extract of conium, and bimeconate of morphia, also, to a great degree. Hydrocyanic acid, on the other hand, did not impair it at all. The action of these poisons on the bronchial fibres does not correspond with that on other contractile tissues, such as the heart and arteries, œsophagus and intestines, and the voluntary muscles; these in many cases having retained their irritability when that of the bronchi had been destroyed. It is possible that some medicinal agents (strychnia, for example,) may impair the contractility of the bronchial fibres by fixing them in a state of tonic spasm."

2. *Pneumatica affecting the aërian membrane.*—The mucous membrane lining the air passages and lungs is the seat of secretion and exhalation and of the action of various medicines which will be noticed among the agents operating on the secernent system (see *Class* VIII. *Eccritica*).

3. *Pneumatica diminishing the want of breath.*—These are agents which act as torporifics. They lessen the activity of the functions, retard the oxidizing processes going on in the animal economy, and consequently diminish the want of oxygen in the system.

Sleep and hybernation are physiological states allied to the pathological condition here referred to. In both states the amount of respiration is diminished.

Syncopal asphyxia is another allied condition. On persons in a state of syncope, deprivation of air has not the same injurious effect as on persons whose functions are in full activity.[2]

Under the influence of agents which diminish the want of breath, the combustion of hydrogen, carbon, phosphorus and sulphur in the system must be reduced, and the amount of excreted oxidized products (water, carbonic, phosphoric, and sulphuric acids) lessened. For obvious reasons, however, it is almost impossible to verify this statement experimentally in the case of hydrogen; and with respect to sulphur, I am unacquainted with any experiments made to ascertain the actual amount of this substance consumed in the system.[3] From Dr. Prout's experiments,[4] however, it appears that spirituous liquors and tea lessen the quantity of carbonic acid exhaled; and Dr. Bence Jones[5] has recently ascertained that the amount of phosphoric acid contained in the urine of patients suffering with delirium tremens was diminished in a remarkable degree when no food could be taken: so that it is obvious that the use of alcohol diminishes the consumption of carbon and phosphorus, and that tea has a similar effect with respect to carbon.

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[1] Under the denomination of muscles of respiration I include the contractile fibres of the bronchial tubes. That they are muscular, is shown by their structure, which is that of the unstriped muscular fibres (Todd and Bowman's *Physiological Anatomy*, vol. i. p. 162); as well as by their being excited to contraction by the galvanic stimulus, as proved in Dr. C. J. B. Williams's experiments (*The Pathology and Diagnosis of the Diseases of the Chest*, 4th edit. p. 320, London, 1840): and that they are in some way concerned in respiration can scarcely, I think, be doubted.

[2] See the art. *Asphyxia* by Dr. Carpenter in *The Library of Medicine*, vol. iii. Lond. 1840.

[3] According to Dr. Ronalds (*Phil. Trans.* for 1846, p. 461) both sulphur and phosphorus are normally excreted by the kidneys in an unoxidized state.

[4] *Annals of Philosophy*, vols. ii. and iv.

[5] *Phil. Trans.* for 1846, p. 449.

It follows, therefore, that if the activity of the combustion processes be reduced, less oxygen will be required, and consequently the necessity for respiration will be diminished. To this is, in some cases, to be ascribed the temporary cessation of dyspnœa obtained by the use of narcotics,[1] and the infrequency or rarity of the respiration in poisoning by opium.[2]

The agents which are believed to have this effect of diminishing the want of breath act primarily on the nervous system and secondarily on the respiratory organs. They will, therefore, come under consideration hereafter (see *Class* VI. *Neurotica*).

4. *Pneumatica influencing the calorific functions.*—It can scarcely, I think, be doubted that the ultimate sources of animal heat are the chemical changes going on in the organism; principally the oxidation of carbon, hydrogen, phosphorus, and sulphur. In a general way, therefore, it may be correctly stated, that agents which promote these changes will augment, and those which check them will lessen, the temperature of the body. The former act as calefacients, the latter as refrigerants.

It by no means follows, however, that the heat of the body is directly or immediately derived from these chemical changes. By the oxidation of zinc both heat and electricity are obtained; and these two forces are so correlated that they are mutually convertible the one into the other; or, at least the one produces the other: thus heat will produce electricity, and conversely electricity produces heat.[3] In like manner, by the oxidation processes going on in the animal body, nervous force and heat are developed;[4] and it appears by no means improbable that a correlation exists between these two forces similar to that which Mr. Grove has shown to exist between the physical forces: the nervous force perhaps may produce heat, and, conversely, heat may excite the nervous force.[1] We know that heat applied to motor nerves produces muscular contractions, and to sensory nerves sensations; and numerous facts may be adduced favouring the notion that the nervous force produces heat. Thus the augmented temperature in the lower parts of the body, sometimes consequent on injuries of the spinal cord, and the flushes or topical extrications of heat frequently observed in nervous and hysterical subjects, favour the notion of the generation of heat by the excitement of the nervous force.

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[1] See Laennec's *Treatise on the Diseases of the Chest*, 2d edition, translated by John Forbes, M.D. pp. 77 and 99, Lond. 1827. Laennec believed that narcotics diminished the necessity of respiration, and to this effect he refers the temporary cessation of dyspnœa under their use in acute mucous catarrh. "If at this period of relief," he observes, "we explore the respiration by the stethoscope, we find it the same as during the paroxysm,—a proof that the benefit obtained consists simply in the diminution of respiration."

[2] In a case of poisoning by opium to which I was called by the late Mr. Edwin Quekett, the respiration was only once in every four or five minutes. By the persevering use of artificial respiration for many hours the patient (an old lady) recovered.—The condition of the respiration and of the aspect of patients narcotised by opium is very different to that of apoplectic coma. The respiration is infrequent, the expression is that of deep and perfect repose, and, in the more advanced cases, death-like: the face is pale, and the features shrunk. There is a total absence of stertor, of swelling or puffiness of the features, of distended veins, and of blueness. It is the Carus of Sauvages (*Nosologia Methodica*).—The efficacy of artificial respiration is in part referable to its rousing the patient and checking the lethargy, as does the muscular exercise or motion effected by dragging the patient up and down the room.—In the case above mentioned I was struck with the facility with which artificial respiration was effected: the respiratory muscles seemed to respond to the artificial aid, as if they were only waiting for some additional assistance to resume their wonted activity.

[3] See Grove *On the Correlation of Physical Forces*, London, 1846.

[4] Matteucci (*Lectures on the Physical Phenomena of Living Beings*, p. 322) suggests that while heat is developed in the body by the combustion of fatty matters and of the substances into which fecula is transformed, the nervous force may be due to chemical actions which take place during the changes which the neutral azotised substances of the tissues undergo.

I have already alluded to the different methods of promoting or raising the temperature of the body (see p. 14). The medicinal agents which produce this effect, and to which the term *calefacients* is applicable, do so by accelerating the circulation and respiration. They are, therefore, the agents commonly called *stimulants* or *excitants*, and as such will be noticed hereafter (see *Class* VI. *Neurotica*, p. 217).

The methods of cooling the body have also been before adverted to (see p. 27). Two classes of medicinal agents are said to have this effect, viz. those which diminish the force and frequency of the circulation, and to which the name of *sedatives* has been given; and another class of substances, supposed to produce their effect by a chemical agency, and which have been called *refrigerants*. The former will be noticed hereafter (see *Class* VI. *Neurotica*); the latter require to be examined now.

ORDER. REFRIGERANTIA. *Refrigerants* or *temperants*.—Medicinal substances which diminish the temperature of the body when preternaturally increased, are denominated *refrigerants* (from *refrigero*, I cool), or *temperants* (from *tempero*, I moderate).

The only agent which in all cases reduces animal heat, is cold, used in the form of ice, cold air, cold baths, cold lotions, cold drinks, &c. These abstract heat, and thereby lower the intensity of the vital movements, diminish vascular action, and reduce the calorific functions (see pp. 23-25).

But there are certain medicinal substances which, by continued internal use, appear to allay febrile heat, and usually promote the secretions, though they have no power of diminishing the ordinary or healthy temperature; and to these the term refrigerants is usually applied.

The substances supposed to produce these effects are acids, acidulous fruits and herbs, acid whey, and some salts.

Acida vegetabilia (see p. 170).
Acida mineralia (see p. 170).
Potassæ bitartras (see p. 178).
Potassæ nitras (see p. 178).
Fructus aciduli.
Herbæ acidulæ.
Serum lactis acidum.

Dr. John Murray[2] thought that refrigerants furnished ready combined oxygen to the system, and in that way prevented so large a quantity of it being consumed in the process of respiration. In support of this hypothesis may be mentioned the observation of Mr. Spalding and Dr. Fyfe,[3] that vegetable diet reduces the consumption of oxygen gas in respiration.

According to this view, pectine (or vegetable jelly), citric, tartaric, and malic acids, should be the most effective alimentary refrigerants, since they contain more oxygen than is requisite to form, with their hydrogen, water (see p. 63).

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[1] See some interesting observations on this subject in the *British and Foreign Medico-Chirurgical Review*, January, 1848, p. 233.

[2] *A System of Materia Medica and Pharmacy*, 5th ed. vol. i. p. 508, Edinb. 1828.

[3] *Annals of Philosophy*, vol. iv. p. 334, Lond. 1814.

Refrigerants are employed in febrile complaints to allay thirst and lower preternatural heat. The general effects and uses of the acid refrigerants have been before noticed (see *ante*, pp. 170—175).

Class VI. *Neurotica.* Medicines acting on the Nervous System.

Medicines which have a specific influence on the nervous system, and thereby modify its functions, are called *neurotica* (*νευροτικά*; from *νεῦρον, a nerve*).

Some of the agents which exercise a topical chemical influence (see *topica chemica*, p. 156), and which after their absorption effect changes in the condition of the blood (see *hæmatica*, p. 168), act also as neurotics. The antispasmodic and saturnine spanæmics (see p. 185), may be referred to as examples. Alcohol also is a neurotic which acts chemically on the tissues; and hydrocyanic acid probably produces some chemical changes in the blood.

But a very large number of neurotics, including opium, morphia, aconitina, strychnia, &c., have no appreciable chemical influence; and, in the present state of chemical and physiological knowledge, their action on the nervous system cannot be explained by affinity.

Most, if not all, neurotics act locally on the nerves, which they paralyse. "The most obvious case of local paralysis of nerves by a narcotic poison," says Müller,[1] "is the dilatation of the pupil and loss of contractile power of the iris consequent on the application of a drop of solution of extractum belladonnæ. In this instance the poison reaches the iris, and the ciliary nerves which are distributed to it, by imbibition. It is evidently a local effect, and not in the slightest degree the result of absorption into the blood, for the pupil of the other eye is unaffected." Aconitina, opium, morphia, conia, &c. are well-known examples of neurotics which exercise a local action on the nerves.

Müller[2] observes that "the change produced in nerves by the immediate application to them of a poison, causing paralysis, is not preceded nor accompanied by any signs of excitement, such as muscular twitchings. The application to the nerves themselves, in a rabbit, frog, or toad, of a watery solution of opium, of strychnine, or of spirituous extract of nux vomica, has, in my experiments, never excited muscular contractions; and I doubt if a narcotic applied directly to a nerve ever excites contractions of muscles: it must, I believe, act through the medium of the spinal marrow and brain."

Some of the neurotics act topically as acrids (see p. 164). The *acro-narcotics* (*e. g.* belladonna and stramonium) and *narcotico-acrids* (*e. g.* colchicum and hellebores) of toxicological writers are of this kind.

The general or remote effects of neurotics are produced not by the extension of the local narcotic effects, but by the passage of the neurotic into the blood, and by the action of the blood, thus impregnated with the deleterious substance, on the central organs of the nervous system and on distant nerves. The tingling and numbness produced in the nerves of the extremities after the introduction of full doses of aconite into the stomach, probably arise from the action of the absorbed aconitina on the nerves of these parts; for the phenomena are analogous to those caused by the topical application of aconite to the nerves.

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[1] *Elements of Physiology*, translated by W. Baly, M.D. Vol. i. p. 630, Lond. 1838.

[2] *Op. cit.* vol. i. p. 626.

The neurotica may be conveniently arranged in two sub-classes; one, called *cerebro-spinalia*, including agents which affect the nervous system of animal life; the other, termed *ganglionica*, comprehending agents affecting the nervous system of organic life.

Sub-class 1. *Cerebro-Spinalia.* Cerebro-Spinals.

This sub-class includes those neurotics which exercise a special influence over one or more of the functions of the brain and spinal cord, and their respective nerves. Those which act on the brain and cerebral nerves may be termed *cerebrals* (*cerebralia*), and such as affect the spinal cord and spinal nerves may be called *spinals* (*spinalia*). But inasmuch as all the cerebrals have some spinal influence, and, conversely, all the spinals some cerebral influence, it is more convenient and correct to include both in one group under the denomination of *cerebro-spinals* (*cerebro-spinalia*).[1]

This sub-class includes the various agents denominated by authors *stupefacientia, narcotica, hypnotica, anodyna, paregorica, inebriantia, exhilarantia, convulsiva, and tetanica.*

A considerable number of cerebro-spinalia are either *organic alkalies*, or owe their activity to these substances: for example, morphia, strychnia, brucia, conia, aconitina, veratria, atropia, nicotina, and the plants in which they are found.

Hydrocyanic acid is an active principle, to which laurel-water and oil of bitter almonds owe their activity.

Volatile oil is another active principle. Camphor, oil of hops, cantharidin, and the substances in which these agents exist, are examples.

Alcohol, ether, chloroform, protoxide of nitrogen, and certain *metallic salts*, are themselves peculiar and powerful neurotic principles.

The cerebro-spinalia produce or prevent sleep, or affect one or more of the functions of the brain and spinal cord, and their respective nerves. These functions are the mind, sensation, and the voluntary and reflex-spinal motions. Although there is no cerebro-spinal agent which exclusively limits its influence to one function, yet, as we employ particular cerebro-spinals for affecting particular functions, we may conveniently arrange the substances composing this sub-class in four orders, as follows.

1. Cerebro-spinals affecting the mental faculties (*phrenica*).
2. Cerebro-spinals affecting sensation (*æsthetica*).
3. Cerebro-spinals affecting the voluntary or reflex-spinal motions (*cinetica*).
4. Cerebro-spinals affecting sleep (*hypnica*).

ORDER 1. PHRENICA (φρενικά; from φρήν, *the mind*). *Phrenics.* Medicines affecting the mental faculties.

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[1] In the two former editions of this work I called these agents *cerebro-spinants* (*cerebro-spinantia*), a term which Oesterlen (*Handbuch d. Heilmittellehre*, 1845.—2te Aufl., 1847) has adopted without acknowledgment. In deference to the opinions of others, I have now substituted the more classical name of cerebro-spinalia.

The following substances are employed as phrenics:—

VEGETABLE.

PAPAVERACEÆ.
  Papaver somniferum—*Capsulæ, Opium, Morphia.*
SOLANACEÆ.
  Atropa Belladonna—*Folia, Atropia.*
  Datura Stramonium—*Folia, Semina.*
  Hyoscyamus niger—*Folia.*
  Nicotiana Tabacum—*Folia.*
LAURACEÆ.
  Camphora Officinarum—*Camphora.*
URTICACEÆ.
  Cannabis sativa, *var.* Indica—*Folia, Resina.*

Alcohol. | Vina. | Ætherea.

Phrenics produce different effects on the mind, and receive different denominations according to the nature of their effect.

- *α*. When they exalt or excite the mind, enliven or exhilarate, they are termed *exhilarants* (*exhilarantia*).
- *β*. When they confuse the intellect and produce delirium, inebriation or phantasms, they are called *inebriants* (*inebriantia, phantastica*).
- *γ*. When they stupefy the mind they are denominated *stupefacients* or *narcotics* (*stupefacientia, narcotica, ναρκωτικά*).

These different effects depend partly on the nature of the phrenic employed, but chiefly on the quantity administered, and on the individuality and the habit of the patient. Wine, for example, taken moderately, exhilarates, in larger quantity inebriates, and, in excessive quantity, stupefies. In one individual "excitement predominates; in another stupefaction; nay, what is only a stimulant to one, is a narcotic poison to another. The opium-eaters, in the East, furnish examples of all these varieties."[1]

The substances in popular and medical use for affecting the mental faculties may be arranged in six groups as follows:—

1. METHYSTICA (μεθυστικά; from μέθυ, *wine*). *Spirituosa* (*alcoholica*); *vina; ætherea; chloroform.* The employment of wine and ardent spirit for the purpose of exhilaration and inebriation is familiar to every one. The ethers produce a similar but more rapid and temporary effect; and I have known intoxication produced by swallowing chloroform. The ethers and chloroform are procured from alcohol, which, as is well known, is obtained by distillation from vinous liquids.

In the effects of the methystica three degrees may be distinguished. The *first* is that of exhilaration or excitement. This is best seen when the quantity is small. When the dose is larger this degree constitutes the first stage of operation. Volition and intellect are excited, but not otherwise disordered. The *second* degree or stage is that of inebriation, in which both the mental faculties and volition are disturbed as well as excited. There is more or less confusion of intellect or delirium, varying in intensity and character in different individuals. Volition is impaired; there is vertigo, thick speech, and inability to stand or walk: the individual reels or falls about when he attempts to walk. As yet sensation exists, though lessened; sensibility to painful and other impressions being diminished. The *third* degree is unconsciousness or stupefaction.

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[1] Feuchtersleben's *Principles of Medical Psychology*, p. 168, 1847.

The individual is now insensible, or nearly so, though sometimes capable of being roused when loudly spoken to.

Convulsions are not common: when they do occur it is usually in young subjects. The breath is impregnated with the vapour of the liquid swallowed. The pupils are generally dilated, sometimes (in the worst cases) motionless; occasionally, especially in fatal cases, contracted. In the stage of stupor the breathing is for the most part slow and soft, yet not unfrequently laborious; rarely stertorous.

Delirium tremens is a brain affection, which may be regarded as an effect of chronic poisoning by alcohol. It combines wakefulness, delirium, and tremor. The delirium is of a peculiar character: it consists in the imagined presence of objects (phantasms), such as cats, rats, and mice, which are supposed to be moving, and which the patient is anxious to seize or to avoid. The amount of phosphates in the urine is remarkably diminished in this disease.[1]

Considered with reference to the state of the mind only, the methystica are employed as exhilarants in mental depression, and as excitants in delirium from exhaustion.

2. MECONICA (μηκωνικά; from μήκων, *a poppy*). *Papaveracea; Opiata.* —*Papaver somniferum; opium; morphia.*

The meconica check the secretions of the bronchial and gastro-intestinal mucous membranes, promote sweating, produce contraction of the iris, relieve pain and spasm, cause sleep, and, in large doses, give rise to the state called *narcotism*, in which the sleep is deep, and the respiration tranquil but infrequent (see *ante*, p. 196, footnote).

Two degrees or stages of their effects may be admitted, viz. excitement and sleep or stupor. The predominance of the one or the other depends on circumstances before adverted to (see *ante*, p. 200).

The general effects on the mental functions, for the production of which opium is chewed and smoked by Eastern nations, are tranquillity and serenity of mind, freedom from bodily and mental uneasiness, a feeling of comfort and happiness, animation and exhilaration. The deleterious effects, on the bodily functions, of opium-eating and opium-smoking will be described hereafter.

The meconica are employed to render persons capable of undergoing great mental exertion and bodily fatigue, and to beneficially modify the condition of the intellectual functions in delirium tremens and in some forms of insanity. These uses will be more fully noticed hereafter.

3. CANNABINA (καννάβινα; from κάνναβις, *hemp*). *Cannabis indica; churrus; gunjah; bang, subjee,* or *sidhee; majoon; hashisch.*

The cannabina, according to Dr. O'Shaughnessy,[2] cause a very agreeable kind of delirium or *fantasia*, augmented appetite, venereal excitement, and impaired volition, followed by insensibility, during which the patient retains any position in which he may be placed. This effect simulates catalepsy. I have found Indian hemp to act as an anodyne, antispasmodic, and soporific. In some cases the pupils seemed unaffected, in others were dilated.

Dr. O'Shaughnessy describes a singular form of insanity occasioned by the incautious use of hemp, and which is as singular as the delirium tremens brought on by the prolonged abuse of spirituous liquors. It is at once "recognised by the strange balancing gait of the patient, a constant rubbing of the hands, perpetual giggling, and a propensity to caress and chafe the feet of all by-standers, of whatever rank. The eye wears an expression of cunning and merriment which can scarcely be mistaken. In a few cases, the patients are violent; in many, highly aphrodisiac; in all that we have seen voraciously hungry: there is no increased heat or frequency of circulation, or any appearance of inflammation or congestion, and the skin and general functions are in a natural state."

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[1] Dr. Bence Jones, *Phil. Trans.*, 1846.

[2] *On the Preparations of the Indian Hemp, or Gunjah, (Cannabis Indica), their Effects on the Animal System in Health, and their Utility in the Treatment of Tetanus and other Convulsive Disorders.* By W. B. O'Shaughnessy, M.D. Calcutta, 1839.

In India, Caubul, Syria, Northern Africa, and other parts of the world, the cannabina are used for the purpose of intoxication. They are both swallowed and smoked.[1]

4. CAMPHORACEA. *Camphora officinarum; camphora.*

Camphor is a popular favourite with some nervous and hysterical females on account of its agreeable effects on "the nerves." Large doses of it occasion confusion of intellect, delirium, impaired volition, convulsions, and insensibility. It is anaphrodisiac.

It has been used to calm the violence of maniacal patients, and to allay excitement of the sexual feelings in nymphomania. In insensibility or profound coma, camphor, in the form of enema, has been found by Dr. Copland[2] highly serviceable by rousing the patient.

5. NICOTIANÆ. *Tobaccos. Nicotiana tabacum; N. repanda; N. rustica; N. persica.*

Several species of *nicotiana* are used for smoking and for yielding snuff. They agree in the general character of their effects, but differ in their strength. *Lobelia inflata* (called Indian tobacco) closely resembles the nicotianæ in its effects.

Tobacco is smoked and chewed on account of its calming and tranquillizing influence on the nervous system. "The soothing and flattering visions, with which the practice of smoking feasts the weak and effeminate mind, lead to its adoption by most classes; but it is an enervating and an emasculating luxury."[3]

Tobacco acts as a nauseating, cardiaco-vascular sedative. It occasions vomiting, purging, weakness and irregularity of pulse, syncope, impaired vision, contracted pupil, giddiness, and confusion of ideas. Paralysis, convulsions, delirium, and stupor, are occasional symptoms.

As a calming, soothing, and hypnotic remedy, smoking is sometimes useful (for those accustomed to the practice) in mental excitement and wakefulness.

6. SOLANACEA MYDRIATICA (*mydriatica*, from **μυδρίασις**, *dilatation of the pupil;* solanaceous substances causing dilatation of the pupil; *phantasmatica,* from **φάντασμα**, *a phantom;* agents creating phantasms; *phantastica*). *Atropa belladonna; datura stramonium;* and *hyoscyamus niger.*

These agents produce dilatation of pupil (see p. 198), long-sightedness (presbyopia), great dryness of throat, cheerful delirium, with phantasms, followed by stupor. The eyes are usually blood-shot. Convulsions are not constant.

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[1] For a very interesting account of the effects of Indian Hemp, see Dr. Moreau's work entitled *Du Hachis et de l'Aliénation Mentale, Etudes Pscychologiques;* Paris, 1845. Reviewed in Forbes's *Brit. and Foreign Medical Review,* vol. xxiii. 1847.

[2] *Dictionary of Practical Medicine,* vol. iii. p. 370.

[3] *Op. supra cit.* vol. iii. p. 404.

The obscurity of vision or blindness produced by these agents is referable chiefly, if not entirely, to the alteration in the refractive action of the eye (see p. 212), by which presbyopia is induced; for it is greatly relieved by the use of magnifying glasses. The difficulty of deglutition depends principally on the extreme dryness of the throat; and hence it is partially relieved by taking water with each mouthful. The hoarse voice or aphonia probably arises from the same cause, for it also is relieved by drinking water.

A scarlet eruption occurs in poisoning by belladonna. Both belladonna and stramonium are acro-narcotics. They produce dilated pupil by topical application (see p. 198).

Hyoscyamus is used as a calming, soothing, and tranquillizing agent in nervous excitability and mania. Belladonna and stramonium are rarely employed for their mental influence. Their other uses will be noticed hereafter.

ORDER 2. ÆSTHETICA (αἰσθητικά; from αἴσθησις, *sensation*). Agents affecting sensation.

As the term *æsthetica* applies to any or all of the senses, it is necessary to qualify it when we apply it to any particular sense. Agents which affect any of the senses may, therefore, be called *æsthetica communia;* those affecting sight,' *æ. optica;* those affecting hearing, *æ. acoustica;* those affecting smell, *æ. osmetica;* those affecting taste, *æ. geustica;* and, lastly, those affecting common sensibility or touch, *æ. haptica.*

Æsthetics are employed in medicine either to heighten sensibility or to lessen it: in the former case they may be termed *hyperæsthetica;* in the latter, *anæsthetica.*

SUB-ORDER 1. HYPERÆSTHETICA (ὑπεραισθητικά; from ὑπέρ, *above* or *over*, and αἰσθητικά). Agents which render sensation more acute.—*Strychnos nux vomica; strychnia; brucia; rhus toxicodendron* (?)

Nux vomica, strychnia, and brucia, heighten the sensations of touch, vision, and hearing, and give rise to various unpleasant or painful sensations in different parts of the body, especially in paralysed parts. Toxicodendron also is said to have produced a return of sensibility, with a feeling of burning and pricking in paralysed parts.

These agents have been employed to excite the sensibility of paralysed parts.

SUB-ORDER 2. ANÆSTHETICA (ἀναισθητικά; from α *non*, and αἰσθητικά). *Narcotica* (ναρκωτικά, from νάρκωσις, *a benumbing*); *anodyna* (ἀνώδυνα, from α *non*, and ὀδύνη, *pain*); *paregorica* (παρηγορικά, from παρηγορέω, *I soothe* or *appease*). Agents which diminish sensibility or relieve pain. The term anæsthetica is commonly applied to agents which diminish common sensibility or sensibility to pain.

This sub-order includes a considerable number of agents, viz. the *methystica*, *meconica*, *cannabina*, and *solanacea mydriatica* before mentioned (see pp. 200—2), to which must be added *aconitum napellus*, *aconitina*, *veratria*, *nitrogenii protoxydum*, *hydrocyanic acid*, and the substances containing it, and the *alkaline cyanides*. These agents considered as anæsthetics may be arranged in two divisions, as follows:—

1. Vapours or gases which, when inhaled, temporarily suspend the common or general sensibility of the body; in other words, produce insensibility, and are thereby fitted for preventing pain during surgical operations and parturition, are the anæsthetics commonly so called. I shall term them the *anæs-*

thetica pneumatica (πνευμᾶτικά; from πνέω, *I breathe*), to distinguish them from other anæsthetic agents.

Those in common use are the vapours of *chloroform* and *ether* (sulphuric ether).

Protoxide of nitrogen and the vapours of *hydrochloric* and *nitric ethers*, of *benzine*, and of *bisulphuret of carbon*, are said to produce similar effects.

By inhalation these vapours are absorbed into the blood. This is proved by the detection of them in different parts of the body (even in amputated limbs), and by their continued exhalation by the breath for some time after the individual has ceased to inhale them.

The blood thus holding in solution the vapour of the anæsthetic agent, acts on the nervous centres, and disturbs or suspends, or even destroys, their functions.

All the functions of the nervous centres are not simultaneously, but successively and progressively, affected. The intellect or mind, and volition or the power of regulating locomotion, are first lost; then sensation and motion; and lastly the power of respiration. The action of certain parts supplied by the ganglionic system of nerves, as the heart and intestines, continues for some time after the death of the individual.

Flourens[1] thus describes the successive and progressive action of ether on the nervous centres:—First the cerebral lobes lose their power, viz. the intellect; next the cerebellum loses its, viz the power of regulating locomotion; afterwards the spinal marrow loses the principle of sensation and motion; and lastly, the medulla oblongata loses its power, viz. the motor principle of respiration; and with this, life is lost.

The effects produced by the inhalation of these agents may be conveniently arranged in three stages: the first stage is that in which the mind is clear, though the feelings are somewhat altered, and volition is exercised. The second stage is that of inebriation, in which both the mental faculties and volition are impaired, but in which consciousness still remains. The third stage is that of unconsciousness or insensibility, or dead drunkenness. Of this third stage there are three degrees:—In the first or mildest, the respiration exists; and muscular twitches, involuntary movements or rigidity of the muscles, and groans and cries, sometimes occur; but no articulate sounds: in one case (that of a man) operated on under the influence of chloroform, at the London Hospital, an imperfect and slight attack of opisthotonos took place. In the second degree, the insensibility is complete, but no movements, except those of respiration, are observed; the breathing is often attended with snoring, and occasionally with stertor: the iris is fixed; and the orbicularis palpebrarum does not contract when touched. In the third degree, the respiration is paralysed, and death occurs.

In a fatal case from the inhalation of chloroform, after insensibility had been induced, the patient (a girl, aged 15,) gave a kick or twitch at the termination of the incision; her lips, which had been previously of good colour, became suddenly blanched, and she spluttered as if in epilepsy. No rally took place, and, within two minutes from the commencement of inhalation, the patient was a corpse.[2]

There is diminished sensibility to pain during the second stage. Complete insensibility to pain exists during the third stage: in some cases it is also found in the second stage. Unconsciousness, therefore, is not absolutely essential to the anæsthetic effect.[1]

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[1] *Comptes rendus*, t. xxiv. No. 8, Feb. 22, 1847.

[2] *London Medical Gazette*, Feb. 11, 1848.

When patients are recovering from the state of insensibility, the inhalation having been discontinued, it often happens that they acquire consciousness, vision, hearing, and the power of speech, without becoming sensible to the pain of an operation.

Every one is now familiar with the application of these anæsthetics for the prevention of pain during surgical operations and parturition. They have also been used with much success in other cases as anodynes, antispasmodics, and soporifics.

2. The second division of anæsthetics consists of solid and liquid agents which when swallowed, injected into the rectum, or applied to the skin, alleviate pain. It includes, therefore, all those substances to which the term *anodyne* has hitherto been usually applied. The agents belonging to this division may be arranged in three groups as follows:—

a. Some of these agents, when applied to the skin or lips, occasion numbness of the part, along with tingling and pricking, somewhat analogous to the feeling which is experienced when sensation is returning to a part which has been "asleep," after the removal of pressure upon a nerve, and which is commonly called "pins and needles." Such agents may be denominated *nerve-benumbers*. The topical effect which they produce is allied to that occasioned by some acrids; but is devoid of the sensation of heat.

Aconitum napellus, *aconitina*, and *veratria*, produce the effects just described.

Tincture of aconite, when taken internally in small doses, produces, especially in hysterical females, tingling, numbness, and various anomalous sensations in different parts of the body. These remote effects probably depend on the topical action of the active principle of the aconite on the nerves through the medium of the blood (see p. 198).

The benumbers are adapted for the relief of neuralgia.

β. Some anæsthetics produce no perceptible alteration in the normal feeling of the parts to which they are applied, though, when taken internally, they become absorbed, and relieve pain. Their anodyne effect seems referable to their influence over the nervous centres, on which they act as stupefacients. These are the agents to which the term *anodyne* is usually applied. This group includes the *meconica*, *methystica*, *cannabina*, and *solanacea mydriatica*. Of these, ether, opium, and morphia, are by far the most certain and effective anodynes for relieving acute pain of internal organs. They are most successful in alleviating spasmodic pain (see *ante*, pp. 200—202).

γ. Another group of agents used for relieving certain kinds of pain includes *hydrocyanic acid*, and substances containing this acid (as *volatile oil of*

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[1] Dr. Snow (*Lancet*, Feb. 12, 1848,) thinks, that in all cases in which patients feel no pain during surgical operations, previous unconsciousness must have existed. I believe this to be an error. An Irishman had his leg amputated, at the London Hospital, under the influence of ether, without experiencing pain; and the sly winks and facetious nods during the inhalations, and the humorous observations made in the intervals, left no doubt in the mind of every person present of his consciousness during the whole period. An imperfect report of the case appeared in the *Times*, and was copied into the *London Medical Gazette*, Jan. 22, 1847. This patient was a spirit drinker.

bitter almonds, cherry-laurel water, &c.), *arsenic, trisnitrate of bismuth, the ferruginea, and disulphate of quina.*

These agents relieve only certain kinds of pain, such as that commonly known as neuralgic; and not always this. They do not act either as benumbers or stupefacients.

Hydrocyanic acid has a very slight benumbing effect on the nerves of common sensation; and, in large doses, occasions sudden loss of intellect, sensation, and volition, usually with convulsions.

In many cases, if not in all, the pain which they relieve is produced by reflection or sympathy. This reflection of impressions which produce sensation is effected by the nervous (probably the spinal) centre.

The agents above enumerated as relieving neuralgia probably do so by their influence on the nervous centre. Hydrocyanic acid is well known to depress the reflex motor functions of the spinal cord, and it is not unlikely, therefore, that it does the same with the reflex sensory functions. The metallic salts, above mentioned as being useful in neuralgia, are valuable agents in relieving certain disorders referable to the reflex motor functions of the cord, such as chorea (see *ante,* pp. 189 and 192).

This group of anæsthetica is applicable to neuralgia in general; but is more particularly serviceable in the neuralgia of certain parts, as of the face (tic douloureux), of the stomach (gastrodynia), and of the bowels (enterodynia).

ORDER 3. CINETICA (κινητικά; from κίνησις, *motion*). Agents affecting the voluntary and reflex-spinal movements.

The cinetica may be considered under four heads, according as they affect the tonicity or the irritability of muscles, the exercise of volition, or reflex-spinal action.

a. Cinetica affecting the tonicity of muscles.—Muscular, as well as some non-muscular, parts possess the property called *tonicity* or *tone,* sometimes termed *retractility.* It is a tendency to passive or slow and moderate contraction not necessarily alternating with relaxation. It is augmented by cold and impaired by heat. It is greatly influenced by, if it be not absolutely dependent on, the cerebro-spinal system.[1]

Pharmaceutical agents which augment the tonicity are called *tonics,* while those which lessen it are denominated *relaxants.*

SUB-ORDER *a.* TONICA (τονικά; from τόνος, *tone*). *Corroborantia* seu *roborantia; euplastica.* Agents which increase the tone of the system.

Dr. Billing[2] gives the following definition of tonics:—"Tonics are substances which neither immediately nor sensibly call forth actions like stimulants, nor depress them like sedatives, but give power to the nervous system to generate or secrete the nervous influence by which the whole frame is strengthened."

The action of a tonic must not be confounded with that of a stimulant. Tonics give strength, stimulants call it forth. Stimulants excite action; but action is not strength: on the contrary, over-action increases exhaustion.[3]

The following is a list of the substances to which the term tonic is usually applied:—

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[1] See Dr. M. Hall *On the Diseases and Derangements of the Nervous System,* p. 78.

[2] *First Principles of Medicine,* p. 92, 4th edit. 1841.

[3] *Ibid.* p. 95.

1. VEGETABLE.

MENISPERMACEÆ.
Cocculus palmatus—*Radix calumbæ.*
POLYGALACEÆ.
Krameria triandra—*Radix rhataniæ.*
AURANTIACEÆ.
Ctirus Limonum—*Cortex fructûs.*
Citrus vulgaris—*Cortex fructûs.*
RUTACEÆ.
Galipea officinalis—*Cortex cuspariæ.*
SIMARUBACEÆ.
Simaruba amara—*Cortex radicis.*
Picræna excelsa—*Lignum.*
LEGUMINOSÆ.
Hæmatoxylon campechianum—*Lignum.*
Acacia Catechu—*Extractum.*
Pterocarpus marsupium—*Extractum* (*kino*).
ROSACEÆ.
Rosa gallica—*Petala.*
Potentilla Tormentilla—*Radix.*
Geum urbanum—*Radix.*
GRANATÆ.
Punica granatum—*Cortex fructûs.*
LYTHRACEÆ.
Lythrum Salicaria—*Radix.*
STELLATÆ.
Rubia tinctorum—*Radix.*
CINCHONACEÆ.
Cinchona: plurimæ species—*Cortex, Quina, Cinchonia.*
Nauclea Gambir—*Extractum* (*Gambir; Catechu*).
COMPOSITÆ.
Taraxacum Dens-leonis—*Radix.*
Taracetum vulgare—*Herba.*
Artemisia Absinthium—*Herba.*
Anthemis nobilis—*Flores.*
Inula Helenium—*Radix.*
ERICACEÆ.
Arctostaphylos Uvæ-ursi—*Folia.*
APOCYNACEÆ.
Strychnos Nux vomica—*Semina; strychnia; brucia.*
GENTIANACEÆ.
Gentiana lutea—*Radix.*
Agathotes Chirayta—*Herba.*
Erythræa Centaurium—*Summitates.*
Menyanthes trifoliata—*Herba.*
POLYGONACEÆ.
Rheum—*Radix.*
Polygonum Bistorta—*Radix.*
Rumex aquaticus—*Radix.*
LAURACEÆ.
Nectandra Rodiei—*Cortex, bebeerine.*
EUPHORBIACEÆ.
Croton Cascarilla—*Cortex.*
URTICACEÆ.
Humulus Lupulus—*Strobili.*
ULMACEÆ.
Ulmus campestris—*Cortex.*
CUPULIFERÆ.
Quercus pedunculata—*Cortex.*
Quercus infectoria—*Gallæ; acidum tannicum; acidum gallicum.*
SALICACEÆ.
Salix: plurimæ species—*Cortex, Salicin.*
SMILACEÆ.
Smilax: plurimæ species—*Radix.*
ACORACEÆ.
Acorus Calamus—*Rhizoma.*
LICHENACEÆ.
Cetraria Islandica.

2. ANIMAL.

Bos taurus—*Fel.*

3. INORGANIC.

Acida mineralia (see *ante*, p. 170).
Alumen (see *ante*, pp. 158 and 178).
Ferruginea (see *ante*, pp. 158 and 189).

Argenti nitras
Bismuthi trisnitras
Cupri sulphas
Zinci sulphas
Zinci acetas
} (see *ante*, pp. 158, 185, 206, and 213).

Besides the preceding, various other substances are by some writers denominated tonics.

"The term tonic," says Dr. Billing, "is applicable to all those medicines which cure chronic inflammation without being either stimulant or directly sedative or depletory." As mercury cures inflammation, both when stimulants are carefully withheld as well as when they are necessarily administered, he considers this metal to be "neither stimulant nor sedative, but tonic; that is, by its specific action on the capillaries, whether directly on their tissue or through the medium of their nerves, it causes them to contract when (though all the injecting force of the heart were taken off by sedative treatment) they would not have had power to close; for, when introduced into the system, it circulates to the capillaries, and gives them tone to contract, analogous to the effect of an astringent applied to external sores. Liquor arsenicalis, nitrate of silver, the sulphates of copper and iron, mezereon, dulcamara, colchicum, &c., have a similar action, some of which are more available than others in particular cases." "Even narcotics frequently become, in an indirect manner, most usefully tonic."

The active principles of the tonics are of five kinds:—

1. *Vegetable alkaloids*, as quina, cinchonia, bebeerine, strychnia, brucia, &c.
2. *Vegetable crystallizable but indifferent principles*, as salicin, cascarillin, gentianin, &c.
3. *Vegetable acids*, as tannic, gallic, chrysophanic, &c. acids.
4. *Animal matter*, bile.
5. *Inorganic substances*. Certain metals, as iron, arsenic, silver, copper, zinc, bismuth, and aluminum, form compounds which are used as tonics. Some of the mineral acids, as the sulphuric, nitric, and hydrochloric, are employed as tonics.

Some of the vegetable tonics are said to owe their bitterness and medicinal activity to a principle to which the terms *materia hermaphrodita*, *materia saponacea*, and *extractive matter*, have been applied. It is described as being of a brown colour, soluble in water and alcohol, insoluble in ether, and becoming insoluble in water by long-continued boiling and by exposure to light and air.

That a substance, or mixture of substances, possessed of these properties may be obtained from various plants cannot be doubted, but it is not probable that chemists have yet succeeded in obtaining a proximate principle to which the term extractive can with propriety be applied. What has hitherto been procured is a mixture or compound of several principles, such as vegetable acids and their combinations with potash and lime, colouring matter, sugar, gum (rendered soluble in alcohol by its combination with other substances), vegetable bases, &c.

The topical effects of the tonics, considered as a class, are not very considerable. Those which contain tannic acid, as well as the mineral astringents, act chemically on the tissues to which they are applied (see *ante*, pp. 94 and 158).

The tonic principles, when taken into the stomach, form, in most cases, new chemical combinations; then become absorbed, and are afterwards thrown out of the system by the excreting organs. Some of them (*e. g.* quina and chrysophanic acid [colouring matter of rhubarb]) have been detected in the blood; some (*e. g.* tannic, gallic, and chrysophanic acids, and quina) have been found in the urine; some (*e. g.* quina) in the milk; and some (*e. g.* chrysophanic acid) in the cutaneous transpiration (see *ante*, pp. 101 and 102). The changes which the mineral substances used as tonics suffer, and the evidences of their absorption and subsequent excretion, have been before adverted to (see *Spanæmica*, p. 169, and *Hæmatinica*, p. 188).

The agents called tonics only act as such in certain states of disease. Under other conditions they act as irritants or stimulants, or even as sedatives.

In the healthy state moderate doses produce no sensible effects, or, perhaps, a slight excitement of the appetite merely, while large quantities give rise to nausea and vomiting. They may then act as sedatives by nauseating. In irritation or inflammation of the stomach and intestines, and in febrile conditions of system, attended with a hot and dry skin, and a furred and dry tongue, tonics act as local irritants and stimulants, and add to the severity of all the morbid symptoms.

Tonics sometimes purge, at others constipate. When diarrhœa arises from, or is kept up by, a weakened state of the intestinal tube, tonics, by restoring strength, may produce constipation. On the other hand, when constipation depends on a debilitated and torpid condition of this tube—a circumstance not uncommon in females—tonics not unfrequently occasion alvine evacuations. Dr. Cullen, having noticed how frequently bitters act as laxatives and purgatives, has inserted them in his list of cathartics.

Tonics are closely related to stimulants; and, on many occasions, the so-called tonic substances act really as stimulants. Thus, in weak but irritable subjects recovering from a protracted state of fever, disulphate of quina will frequently act both as a local irritant and stimulant, and produce nausea, vomiting, furred tongue, a febrile state of system, headache, &c.

Some of the agents employed as tonics produce, when taken in large doses, convulsive movements, or even a tetanic state, giddiness, delirium, &c.

Tonics are employed where the tonicity of the system is defective; that is, in cases of atony or debility, with a soft, flaccid, and loose condition of the soft solids. Properly administered in these cases their true tonic operation is then observed. Their immediate effects are to increase the appetite and assist digestion. After they have been administered for some time, the soft solids (as the muscles, cellular tissue, &c.) become firmer, the muscular strength greater, and the pulse stronger, though not quicker. In fact, all the functions are performed with more energy, and the patient is capable of greater exertion.

Tonics are remarkable for their peculiar and powerful curative agency in certain diseases whose pathology is very obscure. I refer now to the cure of ague by arsenic and quina; of chorea by arsenic and iron; of neuralgia by arsenic, quina, and iron; and of epilepsy by arsenic, silver, and zinc (see pp. 185, 192, 193, and 205). These effects prove the action of tonics on the central organs of the nervous system.

This order may be arranged in three sections, as follows:—

1. ASTRINGENTIA VEGETABILIA PURA.—Pure vegetable astringents. This section comprehends those vegetable tonics which possess considerable astringency with little or no bitterness;[1] such as tannic and gallic acids, oak-bark, nut-galls, uva-ursi, catechu, logwood, rhatany, tormentilla, pomegranate-rind, bistort, and kino. These agents are principally remarkable for causing local contraction and corrugation (or astriction) of the tissues. They contract and give greater density to the muscular fibres, diminish the calibre of the blood-vessels and exhalants, and thereby check hemorrhage (whence their denomination of *styptics*), and diminish secretion and exhalation when applied to mucous membranes or other secreting surfaces. In the mouth they give rise to a peculiar sensation of roughness and stypticity. These effects have been ascribed to a chemical or physical agency. Thus Dr. Cullen places astringents among substances acting on the simple solids, though, in another part of his treatise, he admits that they act on the living as well as on the simple solids. The late Dr. Adair Crawford[2] ascribed the effects of both astringents and bitters to their influence in promoting the cohesion of the animal fibre. He immersed some pieces of intestines, of skin, &c. in various bitter and astringent infusions, while others were placed in water, merely as a standard; and he then observed the comparative weights required to break them, from which he inferred the relative strength of different tonics. But this mode of reasoning naturally leads to erroneous inferences, since the vital powers of the system are quite overlooked. The relaxed state of parts, which astringents are useful in obviating, depends not on a mere mechanical or chemical alteration, but in some change in the state of vital powers; and, therefore, the agents

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[1] For some observations on the distinction between astringency and bitterness, see Perceval's *Essays*, vol. i. 2d edit. Lond. 1772.

[2] *An Experimental Inquiry into the Effects of Tonics*, *&c.* 1816.

which counteract it must have some other than a mere physical or chemical action. Moreover, the results obtained by Dr. Crawford depended probably on the different degrees of antiseptic power possessed by the substances employed. Astringents produce the constitutional effects of the bitter tonics: administered in moderate doses, they promote the appetite, assist digestion, and increase the tone and vigour of the general system. They are capable of fulfilling the same therapeutic indications as the bitter tonics. Thus, they have the power of preventing the occurrence of a paroxysm of intermittent fever; and in cases of debility are often useful, independently of their power of checking debilitating discharges. But this group is principally employed for its local effects, to obviate relaxation of fibres and tissues, and to prevent or check excessive discharges.

2. AMARA.—Bitter tonics. These are characterised by bitterness. They may be arranged in five sections, as follows:—

α. Amara pura seu simplicia.—Simple or pure bitters. This group includes those vegetable tonics which possess bitterness with little or no astringency or aroma. To this division are referred quassia, simaruba, gentian, chirayta, common centaury, and menyanthes. To these must be added, the vegetable alkaloids and the crystallizable indifferent principles before mentioned. These remedies are employed to promote the appetite and assist digestion in atonic and enfeebled conditions of the stomach; as general tonics in feebleness and debility of the whole system, and especially of the muscles; as antiperiodics in intermittent diseases; and as anthelmintics. Their beneficial operation in expelling intestinal worms has been referred to their poisonous influence over these parasitical animals, but ought perhaps rather to be ascribed to their improvement of the condition of the alimentary canal, and to the removal of those states which favour the production of these beings. The power which they possess of retarding the acetous fermentation may, perhaps, contribute to their beneficial operation in some dyspeptic cases accompanied with acidity and flatulence.

β. Amara mucilaginosa.—Mucilaginous or demulcent tonics, which contain, besides a bitter principle, mucilage or starchy matter, but little or no aroma or astringency. This section includes calumba, and Iceland moss. In addition to the properties of the simple bitters, they possess demulcent and slightly nutritive properties, which they owe to the presence of starch.

γ. Amara aromatica seu excitantia.—Aromatic bitters, which possess bitterness, with an aromatic flavour (derived from the presence of volatile oil), but little or no astringency. This group contains wormwood and elecampane, cascarilla, angustura-bark, orange and lemon peel, and hops. These substances possess the combined properties of aromatics and bitter tonics, and are, therefore, useful where these are indicated.

δ. Amara resolventia seu laxativa.—Resolvent or laxative bitters. To this section are referred taraxacum, rhubarb, aloes, and extract of ox bile. In addition to being bitter tonics, these agents act as laxatives or purgatives. They are employed as mild alterative or resolvent tonics in chronic visceral affections, especially dyspepsia, liver complaints, uterine disorders, &c.

ε. Amara astringentia.—Astringent bitters. This group contains those vegetable tonics which possess both bitterness and astringency in an eminent degree. It includes cinchona-bark, elm-bark, and willow-bark. It combines the effects of both bitters and astringents, and is by far the most important group of the class, since it contains cinchona-bark, the most powerful of the vegetable tonics.

3. TONICA MINERALIA.—Mineral tonics. This section includes the metallic tonics (see *ante*, pp. 158, 185, and 188), the mineral acids (see *ante*, p. 170), and alum (see *ante*, p. 178).

SUB-ORDER β. RELAXANTIA DEPRIMENTIA.—Depressing relaxants. These are agents which depress and lower the tonicity of fibres, and thereby cause relaxation of muscular and other tissues.

To this sub-order belong the *nauseating emetics*, especially emetic tartar (see *emetica*), the *sedatives*, particularly tobacco (see *sedativa*), and the *anæsthetica pneumatica* (see *ante*, p. 204).

These agents are employed to lower the powers of the muscular and vascular systems. Thus they are administered to cause relaxation of the muscles, and thereby to enable the surgeon to effect the reduction of dislocations of the larger joints, and of strangulated herniæ. When they are employed to reduce the power of the heart and arteries they are denominated sedatives, and as such will be noticed hereafter.

β. *Cinetica affecting the irritability of muscles.*—Irritability is a property peculiar to muscular structures, and, unlike tonicity, is increased by warmth, and decreased by cold.

Most physiologists regard irritability as an inherent property in the muscles themselves; but some[1] consider it to be derived from the spinal cord. However this may be, it is admitted by all that the irritability of muscles is greatly under the influence of the nervous system.

The contraction of muscular fibres may be induced by the nervous stimulus (*vis nervosa*) and by stimuli acting directly on the muscular fibre.

The antispasmodic and paralysing effect of opium, and the spasmodic or tetanic condition induced by nux vomica, are referable, at least chiefly, to changes effected in the nervous stimulus, and not to alterations of the contractility of the muscular fibre. For Matteucci[2] found that, in frogs poisoned by opium or nux vomica, when the excitability of the nerves was destroyed, and when the electric current which was applied to them no longer occasioned muscular contractions, the muscles themselves, when submitted directly to the action of the current, underwent contraction.

The cinetica which act on the irritability of muscles are of two kinds,—those which augment, and those which lessen this property. The former produce spasm or convulsions, and may be termed *spastica*; the latter produce a paralysed state, and may be called *paralytica*.

SUB-ORDER γ. SPASTICA (*σπαστικά*, from *σπάσις*, *a convulsion or spasm*); *convulsiva*; *tetanica*. Agents which augment the irritability of muscles and excite spasm or convulsion.—This sub-order includes *strychnia* and *brucia*, and all the vegetable substances containing these alkaloids, as the seed and bark of the stem of *strychnos nux vomica*, the seed of *strychnos ignatia*, snake wood (*lignum colubrinum*), the *upas tieuté*, and perhaps the seed of *cerbera tanghin*. These agents, as I have before stated (see p. 203), excite common sensibility, and act as *hyperæsthetica*. As therapeutical agents they are used, in torpid or paralytic conditions of the muscular system, under regulations which will be pointed out hereafter.

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[1] Dr. M. Hall, *Medico-Chirurgical Transactions*, vol. xxii.

[2] *Lectures on the Physical Phenomena of Living Beings*, pp. 255—256, Lond. 1847; *Traité des Phénomènes Electro-Physiologiques des Animaux*, pp. 241—242, Paris, 1844.

Cantharides appear to augment the irritability of at least some muscular parts: the neck of the bladder, for instance; in the treatment of weakness and paralysis of which they are frequently employed with advantage.

CATALEPTICA.—According to Dr. O'Shaughnessy's observations, before referred to (see *ante*, p. 202), *cannabis indica* produces a cataleptic condition. In this state the muscles are moderately contracted, but flexible and pliant, and the limbs retain any position or attitude in which they may be placed. It is, therefore, a modified and moderate degree of tonic spasm; and agents which induce it may be called *cataleptica (καταληπτικά*; from *κατάληψις, catalepsy)*. Indian hemp has been used as an antispasmodic, anodyne, and soporific.

SUB-ORDER δ. PARALYTICA (παραλυτικά; from παράλυσις, *paralysis*).—Agents which diminish the irritability of muscles and occasion weakness or paralysis.

This sub-order contains *conium maculatum* and its alkaloid *conia*, as well as several of the subdivisions of the order *Phrenica* before noticed; as the *meconica, methystica, nicotianæ*, and *solanacea mydriatica*.

These agents are important remedies in the treatment of spasmodic affections; and when used in these cases they are termed *antispasmodics* (*antispasmodica*).

Cinetica affecting the movements of the iris.—The movements of the iris are influenced by many medicinal agents.

1. Some cause *mydriasis* or preternatural dilatation of the pupils. These may be called *mydriatica*. Belladonna, stramonium, and hyoscyamus, are the most important agents possessing this property (see *ante*, pp. 199 and 202). They paralyse not only the muscular fibres of the iris, and thereby cause mydriasis, but also the ciliary muscle, and in consequence impair the adjusting faculty of the eye[1]. They are used by oculists for producing dilatation of the pupil.

2. Some agents cause *myosis* or preternatural contraction of the pupil. These may be termed *myositica*. Opium and morphia produce this effect (see *ante*, p. 201).

Indications for the use of the mydriatica or myositica in cerebral diseases have been drawn from the condition of the pupil. Thus, Dr. Graves[2] has proposed the employment of belladonna in those cases of fever which are attended with contraction of pupil; and Dr. Holland[3] has suggested that in this condition of pupil opium is contra-indicated.

γ. *Cinetica affecting volition.*—Certain muscles, called voluntary, are under the influence of the *volition* or *will*.

1. The influence of the will over these muscles may be increased by stimulating liquors. In the first degree of the effect of the methystica (see *ante*, p. 200) volition may be said to be in excess.

In paralysis, the power of the will over the voluntary muscles is lessened or destroyed. In such cases strychnia and cantharides sometimes augment the influence of volition by heightening the irritability of the muscles.

In some cases, as in chorea and delirium tremens, irregularities occur in the movements of the muscles under the influence of the will. Agents which prevent these and enable the will to control and regulate the contraction of the muscles in the performance of its acts, may be said to increase and render more perfect the influence of volition over the muscles. Opium and morphia act thus in delirium tremens (see *ante*, p. 201); and arsenic, iron, and zinc, in chorea (see *ante*, pp. 185 and 192).

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[1] See Todd and Bowman's *Physiological Anatomy*, vol. ii. pp, 27, 47, and 48.

[2] *Dubl. Journ. of Medical Science*, July 1, 1838.

[3] *Medical Notes and Reflections*, p. 427. 2d edit. 1840.

2. The influence of the will over the muscles is lessened by inebriants and stupefying agents (see *ante*, p. 201). Morphia and opium are the cerebro-spinals usually resorted to in mania to depress excessive voluntary action. They are generally used under the denomination of sedatives.

δ. *Cinetica affecting the reflex-spinal functions.*[1]—The reflex-spinal acts are independent of the will. They are accomplished by the agency of the *vis nervosa* through the medium of the incident and reflex nerves and their connecting centre.

1. Some medicinal substances excite reflex actions. The sneezing caused by sternutatories, and the vomiting occasioned by emetics, are examples of reflex actions excited by medicines. These reflex acts are accompanied by augmented secretion (see *Class* VIII. *Eccritica*).

2. Some medicinal agents exalt the reflex function. In this exalted state "stimuli which have no such effect naturally induce morbid and even spasmodic actions" (Hall). Strychnia exalts the reflex function. Under its influence animals are thrown into convulsions by very slight causes, as by the contact of external bodies, and by attempts to walk and to respire. Cantharides exalt the reflex function of the cervix vesicæ, and are useful in enuresis.

3. Some medicinal agents depress the reflex functions. Hydrocyanic acid, conium, belladonna, stramonium, and cannabis indica, may be quoted as examples. Hydrocyanic acid is a valuable remedy for allaying vomiting, hiccup, palpitation, and convulsive cough. Stramonium gives great relief in attacks of spasmodic asthma (see *ante*, p. 195).

In celerity of effect and rapidity with which they prove fatal, no agents exceed, and few equal some of those of this group, such as hydrocyanic acid and conia (the active principle of hemlock).

The phenomena (sudden loss of sensation, of volition, and of consciousness, with convulsions,) caused by poisonous doses of hydrocyanic acid resemble those of epilepsy. Similar symptoms also sometimes occur from the loss of large quantities of blood. The analogy between these three conditions (*i. e.* hydrocyanic poisoning, epilepsy, and the effect of hemorrhage,) is further shewn by the fact that the symptoms of all are relieved by ammonia.

Alcohol, ether, ammonia, the fetid gum-resins, the empyreumatic oils and resins, and the essential oils, are valuable *antispasmodics* in convulsive and spasmodic diseases occurring in weakly subjects and unattended by inflammation. They "act as stimulants to the heart and vessels, and to the cerebral functions, [and] seem to operate as sedatives to the medullary system."[2] (See *Stimulantia*).

Certain metallic substances (arsenic, zinc, iron, silver, and copper,) "have some power in reducing the excitability of the spinal excito-motory system," and are useful in relieving chorea, epilepsy, and other convulsive affections, (see *ante*, pp. 185 and 192).

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[1] On this subject the reader is referred to Dr. Marshall Hall's valuable works: *Memoirs on the Nervous System; Diseases and Derangements of the Nervous System;* and his *New Memoir on the Nervous System.*

[2] *Principles of Medicine*, by Dr. C. J. B. Williams, p. 72.

ORDER 4. HYPNICA (ὑπνικά; from ὕπνος, *sleep*). Agents affecting sleep.

The hypnica are of two kinds,—those causing sleep, and those which check or prevent it. The former are called *hypnotica*, the latter may be termed *agrypnotica*.

SUB-ORDER α. HYPNOTICA (ὑπνωτικά; from ὑπνόω, *I lull to sleep*). *Hypnopœi; somnifica; somnifera.* Agents causing sleep.

The most important hypnotics are the agents already referred to under the order *Phrenica*, especially the *meconica*, *methystica*, *cannabina*, and *solanacea mydriatica*. To these may be added *lactuca sativa*, *l. virosa*, *lactucarium*, *myristica officinalis*, and *humulus lupulus*.

SUB-ORDER β. AGRYPNOTICA (ἀγρυπνωτικά; from ἀγρυπνόω, *I cause to lie awake*). *Anthypnotica.* Agents which cause wakefulness.

One of the most powerful preventers of sleep, especially in the constitutions called nervous, is *tea* (particularly strong green tea). *Coffee* also appears to have an analogous effect. *Digitalis*, which agrees with tea in some of its effects, checks sleep when taken in full doses. *Vinegar* is considered by Orfila to counteract the narcotic effects of opium after the poison has been evacuated from the stomach.

LOCALITY AND QUALITY OF THE ACTION OF THE CEREBRO-SPINALIA.—Most of the differences observed in the operation of the cerebro-spinalia arise from different parts of the nervous centres being affected, or from the same parts being unequally acted on.

The attempts hitherto made to localize the action of the cerebro-spinalia have not been attended with success. Flourens[1] thinks that opium acts specifically on the cerebral lobes; that belladonna, in a limited dose, affects the tubercula quadrigemina, and, in a larger dose, the cerebral lobes also; that alcohol, in a limited dose, acts exclusively on the cerebellum, but, in a larger quantity, affects also neighbouring parts; and, lastly, that nux vomica more particularly influences the medulla oblongata.

One source of difficulty which attends all attempts made to ascertain the nature of the changes which the cerebro-spinalia induce in the nervous centres, is the fact that similar symptoms attend dissimilar affections.

Thus *coma* may be induced by compression of the cerebrum or by loss of blood. *Delirium* may arise from irritation of the cerebrum or from loss of blood. *Convulsions* may be produced by irritation, or lesion of the medulla oblongata and spinalis, or by loss of blood. *Paralysis* may arise from lesion of the encephalon, destructive injury of the medulla oblongata or spinalis, and loss of blood.

Alterations in the quantity or quality of the blood supplied to the different parts of the cerebral and spinal systems, are the primary causes of the changes which the cerebro-spinalia produce in the condition of the functions of these systems.

Augmented arterial action, or venous congestion, sometimes attends the operation of the cerebro-spinalia. Flourens declares that opium, belladonna, alcohol, and nux vomica, give rise to phenomena resembling those which attend mechanical lesions of the parts on which he asserts these agents operate (see above); and furthermore he states, that in birds it is possible to observe, through the cranium, changes of colour [some alterations in the vascular condition of the parts] which these organs effect in the brain: but, in repeating his experiments, I failed in observing the changes referred to.

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[1] *Recherches expérimentales sur les Propriétés et les Fonctions du Système Nerveux dans les Animaux vertébrés*, pp. 254, 258, 261, and 262, Paris, 1824.

I have already noticed the attempts made to explain the action of alcohol on the nervous centres on physical and chemical principles (see *ante*, pp. 87—88, 93, and 109).

Alterations effected in the qualities of the blood by abnormal changes going on within the system, may, in some cases, be the cause of insanity[1].

MODE OF DEATH.—As the sub-class cerebro-spinalia includes the most energetic and swiftly acting poisons, the mode in which these agents produce death becomes a most interesting topic of inquiry; the more especially so, as the consideration of the subject leads to some practical conclusions as to the most appropriate methods of treating cases of poisoning by these substances.

Usually, if not invariably, the deadly effect begins in the cerebro-spinal system, and is produced by the action of the poison contained in the blood on the nervous tissue. In some cases, perhaps, the primary effect may be on the blood, the vitality of which becomes destroyed.

When the deadly effect begins in the cerebro-spinal system, death is occasioned by apnœa or by syncope, or by both.

1. *Death by apnœa.*—In death by apnœa or breathlessness the respiration ceases before the stoppage of the heart's action.

Apnœa may be induced by paralysis of the muscles of respiration, or by spasm of these parts.

Paralytic apnœa is produced by conium, opium, hydrocyanic acid, belladonna, stramonium, and various other agents. It depends on defect of the reflex or excito-motory action.

These are the cases in which it has been proposed to prolong life by artificial respiration until the effect of the poison has passed off. The proposition is not supported merely by its ingeniousness and plausibility, but by experience. The following is a case in point, related by Mr. Whateley, and quoted by Dr. Christison[2]:—A middle-aged man swallowed half an ounce of crude opium, and soon became lethargic. He was roused from this state by appropriate remedies, and his surgeon left him; but, the poison not having been sufficiently discharged, he fell again into a state of stupor; and when the surgeon returned, he found the face pale, cold, and deadly, the lips black, the eyelids motionless, so as to remain in any position in which they were placed, the pulse very small and irregular, and the respiration quite extinct. The chest was immediately inflated by artificial means; and, when this had been persevered in for seven minutes, expiration became accompanied with a croak, which was gradually increased in strength till natural breathing was established; emetics were then given, and the patient eventually recovered.—A most interesting case of recovery from poisoning by opium, by artificial respiration, has been detailed by Mr. Howship.[3]—Another case I have already (see *ante*, p. 196) briefly noticed.

I have several times restored animals apparently dead, from the use of hydrocyanic acid, merely by keeping up artificial respiration; and Sir Benjamin Brodie has done the same with animals apparently killed by the oil of bitter almonds.

In a case of complete insensibility from intoxication, related by Mr. Sampson,[4] the comatose state was thought to arise, not from apoplexy, "but from torpor of the brain, in consequence of that organ being imperfectly supplied with blood not duly oxygenated; for the shrill tone and extreme difficulty of respiration shewed the existence of collapse of the glottis, and imperfect transmission of air into the lungs, which might be accounted for by a paralysed state of the eighth pair of nerves and recurrent branches." Tracheotomy was performed, and with complete success: in about half an hour the respiration was regular and easy through the wound.[1]

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[1] On this subject, see *Observations on the Proximate Cause of Insanity*, by James Sheppard, M.R.C.S., *being an Attempt to prove that Insanity is dependent on a Morbid Condition of the Blood*, Lond. 1844. Also, *Du Hachish et de l'Alienation Mentale, Etudes Psychologiques*, par J. Moreau, Paris, 1846 (Forbes's *Brit. and Foreign Med. Rev.*, vol. xxiii).

[2] *Treatise on Poisons*, p. 680, 3d edit.

[3] *Medico-Chirurgical Transactions*, vol. xx. p. 86.

[4] *Medico-Chir. Trans.* vol. xx. p. 46.

Spasmodic apnœa is of two kinds, laryngeal and thoracic. In *laryngeal* spasmodic apnœa the larynx is spasmodically closed. This condition occurs when an attempt is made to inspire carbonic acid and some other gases (see *ante*, p. 113). In *thoracic* spasmodic apnœa the muscles of respiration are thrown into a spasmodic state, whereby respiration is stopped. In this case reflex action is augmented. Strychnia, brucia, and the substances containing these alkaloids, act in this way.

2. *Death by syncope.*—In death by syncope the heart ceases to beat before respiration stops.

Syncope may be induced by paralysis of the heart, or by spasm of this organ.

Paralytic syncope is produced by tobacco, foxglove, aconite, the upas antiar, and probably by several other poisons.

In poisoning by agents which paralyse the heart it has been proposed to stimulate this organ by slight galvanic shocks, in order to avert the fatal termination. Even acupuncture has been advised, if the patient appeared *in articulo mortis*. Bretonneau[2] has repeatedly punctured the brain, heart, lungs, and stomach of young dogs without the least inconvenience; and Carraro[3] has successfully tried this practice on animals in a state of asphyxia.

Spasmodic syncope is sometimes the cause of death. "In sudden death from drinking a quantity of raw spirits, or of very cold water when the body is heated, the heart has been found contracted."[4]

Sub-class 2. *Ganglionica.* Ganglionics.

These are medicinal agents which affect the sensibility or muscular motion of parts supplied by the ganglionic or sympathetic system of nerves.

The sympathetic nerve exercises a threefold function: it acts as a sensitive nerve to the parts to which it is distributed; it is a motor nerve for certain muscular parts; and it exercises an influence on the contractility of the bloodvessels and on the functions of nutrition and secretion. But inasmuch as the influence of medicines on the organic functions of this nerve are very obscure, and as I have devoted a special class (*Eccritica*) to medicines acting on the secernent system, I have thought it advisable to include under the denomination of ganglionica those agents only which affect the sensation or the motion of parts to which this nerve is distributed.

1. *Affecting the heart and arteries.*—Sometimes we are called on to augment the frequency and force of the heart's action. We endeavour to do this by the agents called *stimulants*. Sometimes our object is to reduce the force and frequency of the action of the heart by the agents termed *sedatives*. At other times we are required to controul irregularities of the heart's action, or to appease acute pain referred to the heart.

For irregularities (such as palpitation, &c.) of the heart's action we have no particular class of remedies. Our treatment must vary with the causes producing them. For painful affections referred to the heart, (such as the pain of angina) our most powerful remedies are the anæsthetics before mentioned (see p. 203), especially opium and ether. On the present occasion we have to notice only two classes of agents, viz. stimulants and sedatives.

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[1] Dr. Marshall Hall (*On the Diseases and Derangements of the Nervous System*, p. 280,) considers the case to have been one of "paralysis of the pneumo-gastric nerve and of the dilator muscles of the larynx;" and that the same condition occurs, not only in intoxication, but probably in other cases of coma, as in that of apoplexy, of epilepsy, from opium, &c.

[2] Bayle, *Travaux Thérapeutiques*, t. i. p. 432.

[3] *Expériences sur des animaux asphyxiés et ramenés à la vie par l'acupuncture du cœur*, in Bayle, *op. cit.* t. i. p. 495.

[4] *Principles of Medicine*, by C. J. B. Williams, M.D. p. 375, Lond. 1843.

ORDER 1. STIMULANTIA (from *stimulus*, a goad or spur); *excitantia; incitantia; calefacientia; sthenica; hypersthenica; diffusible stimuli.*[1] "A stimulant is that which, through the medium of the nervous system, increases the action of the heart and other organs by calling forth the nervous influence, or by facilitating the extrication of it in them" (Billing[2]).

Great confusion of ideas and of language has existed with respect to the distinction between *stimulants, sedatives, narcotics,* and *tonics.* The real difference between them has been ably and clearly pointed out by my friend Dr. Billing. "Stimulants," he observes, promote the extrication of nervous influence, as evinced by increased action; sedatives the reverse. Narcotics do not appear to alter the quantity of nervous influence, but merely to impede its communication." Tonics, on the other hand, "neither immediately nor sensibly call forth actions like stimulants, nor depress them like sedatives, but give power to the nervous system to generate or secrete the nervous influence by which the whole frame is strengthened."

The agents used as stimulants frequently contain, besides their stimulating principle, another agent endowed with different properties. Thus cinnamon contains, besides its stimulating principle (*volatile oil*), an astringent substance (*tannic acid*); cascarilla and chamomiles contain both a stimulating (*volatile oil*) and a tonic principle (*bitter extractive*). Such agents, therefore, possess a two-fold power.

Sometimes the same principle produces, under different circumstances, apparently different effects. Thus brandy in moderate quantities acts as a stimulant; but taken in excess it overpowers the brain, exhausts the nervous power, and impedes its generation, disengagement, and communication; thus acting both as a sedative and narcotic.

The topical action of stimulants is not necessarily accompanied with any obvious changes, either chemical or anatomical. Some stimulants act chemically on the parts with which they are placed in contact; *e. g.* alcohol and ammonia (see *ante*, p. 94): and many of them operate as acrids (see p. 164), and produce hyperæmia of the parts to which they are applied. But these effects are not produced by all agents when acting as stimulants, and, therefore, cannot be considered as essential to their action. All affect the gustatory organ; their taste being warm, pungent, and acrid. Most of them produce a sensation of heat and pain when applied to delicate parts of the skin or to the mucous surfaces. Swallowed in moderate quantities, they give rise to a sensation of warmth in the stomach, promote the contraction of the muscular coat of the stomach and intestines, and thereby expel gaseous matters, and assist digestion. In general they produce hyperæmia and increased secretion of the mucous follicles of the gastro-intestinal surface. In larger quantities they excite thirst, and often give rise to nausea or vomiting.

The active principle of most, if not all of them, becomes absorbed, in some cases, perhaps, after having undergone a greater or less chemical change. Ether, alcohol, and the volatile oils, are rapidly absorbed; the resinous substances more slowly. Those which are very slowly absorbed are frequently in part evacuated with the excrements before sufficient time has elapsed for their total absorption. Many of them have been recognized in the blood by their odour (*e. g.* turpentine, alcohol, camphor, the odorous principle of musk, and assafœtida, and Dippel's oil, see *ante*, p. 101). These, therefore, have been absorbed unaltered. A very large number of them has been recognized in the secretions by their unaltered odour (see *ante*, pp. 101 and 102). In the urine and breath they have been especially recognized. In some cases, however, the odour has undergone a change; as in the case of the oil of turpentine, which communicates a violet odour to the urine.

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[1] In the language of Brown, *diffusible stimuli* are stimuli which possess an operation as much quicker and more powerful than that of the articles of diet, as their operation is of shorter duration. (*The Works of Dr. John Brown*, vol. ii. p. 230, Lond. 1804.) "The most weak degree of the diffusible stimuli are the white wines, except madeira, canary, good sherry; and the red wines, except port, and spirits produced by distillation, so diluted, as to equal the strength of the wines, or exceed it a little. Still higher than these are the latter taken pure; and higher still those which have undergone many rectifications; the strength of which is in proportion to the quantity of water expelled, and of the alcohol retained. A higher place in the scale is claimed by musk, volatile alkali, camphor; our trials of which are not yet so complete as to ascertain its force exactly: next comes ether, and, last of all, opium."

[2] *First Principles of Medicine*, by A. Billing, M.D. A.M. 4th edit. p. 77, 1841.

While in the blood they act as stimulants to the heart and blood-vessels, and increase the frequency and fulness of the pulse. They do this probably by coming in contact with the surfaces of these parts, the organic nerves of which are susceptible of the impression of the stimulating particles.

In their passage out of the system through the secretory organs, stimulants act as topical agents, and augment secretion (see *ante*, p. 110). Hence we find among them some of our most powerful and effective expectorants, sudorifics, and diuretics. Exanthematous eruptions are produced by some of them (*e. g.* copaiva, cubebs, &c.)

The augmented action of the heart and arteries is attended with quickened respiration and an increase of the temperature of the superficial and remote parts of the body: whence the stimulants are frequently termed *calefacients*.

The brain and spinal cord are stimulated to a more active performance of their functions by the more copious supply of blood which they receive. In some cases functional disorder of these parts is produced.

In this way, the stimulants, by causing an increased supply of blood to the various parts of the body, act physiologically as functional exalters, or pathologically as exciters of a febrile state.

Stimulants are used for various purposes, of which the following are the most important:—

1. As topical stimulants or *acrids*. The uses of these have been already briefly noticed (see pp. 164—166).

2. As stimulants to the gastro-intestinal canal they are frequently employed. When administered in dyspeptic cases to promote digestion they are called ***stomachics*** (*stomachica*, στομᾰχῐκά); and when given to dispel flatulence and relieve colicy pain they are termed *carminatives* (*carminativa*; from *carmen*, a charm), or *physagogues* (*physagoga*; φυσαγωγά, from φῦσα, *flatus*, and ἀγωγός, *carrying off*).

3. As stimulants to the heart and vascular system they are employed under the name of *cordials*, (*cardiaca*; καρδιακά, from καρδία, *the heart*, also *the upper orifice of the stomach*), or *restoratives* (*analeptica*; αναληπτικά, from ἀνάληψις, *recovery* or *restoration*).

4. As stimulants to the brain they are used under the denomination of *nervines* (*nervina*), to arouse the energies and correct certain disorders of the nervous system. When these disorders are of a spasmodic nature the remedies often bear the name of *antispasmodics* (*antispasmodica*); and when the malady is an hysterical one, they are termed *antihysterics* (*antihysterica*).

5. As stimulants to the secreting organs they are frequently used to increase, to alter, and, in some cases, to check secretion.

When used to increase secretion they are called *evacuants* (*evacuantia*); and, according as they act on the bronchial membrane, the skin, the kidneys, the uterus, &c., they bear the name of *expectorants* (*expectorantia*,) *sudorifics* (*sudorifica*), *diuretics* (*diuretica*), *emmenagogues* (*emmenagoga*), *diuretics* (*diuretica*), &c. (See Class VIII. *Eccritica*).

In asthenic fluxes from the mucous surfaces, stimulants are frequently used to modify and check secretion. In such cases they appear to act as astringents. The efficacy of brandy and spices in diarrhœa,—of cubebs, copaiba, and cantharides in leucorrhœa and gonorrhœa,—and of the fetid gums and balsams in bronchorrhœa,—must be familiar to every one. These different agents probably act topically, through the circulation, on the secreting organs; but how is uncertain. In a general way they may be said to operate on the principle of counter-irritation (see *ante*, pp. 123—126).

Stimulants are the remedies for asthenic disorders. The general indication for their employment is exhaustion. They are well adapted for certain nervous and spasmodic diseases, as hysteria; in which there is great nervous excitement, a feeble circulation, and debility.

They are contra-indicated in maladies of a sthenic character; in acute inflammation, ardent fever, hyperæmia, and plethora.

The active principles of the stimulants are *volatile oil*, *resin*, *benzoic* and *cinnamic acids*, *ammonia*, *phosphorus*, and the *methystica*.

The stimulants may be arranged, according to the nature of their active principles, in six sub-orders, as follows:—the *æthereo-oleosa*, the *resinosa*, the *ammoniacalia et empyreumatica*, the *excreta animalia*, *phosphorus*, and the *spirituosa etætherea*.

SUB-ORDER *a*. ÆTHEREO-OLEOSA VEGETABILIA.—These are vegetable stimulants which owe their medicinal powers to volatile oil wholly or chiefly.

- MAGNOLIACEÆ.
  - Drimys Winteri—*Cortex*.
- CRUCIFERÆ.
  - Cardamine pratensis—*Herba*.
  - Cochlearia Armoracia—*Radix*.
  - " officinalis—*Herba*.
  - Sinapis alba—*Semina*.
  - " nigra—*Semina*.
- POLYGALEÆ.
  - Polygala Senega—*Radix*.
- AURANTIACEÆ.
  - Citrus Aurantium—*Cortex fructûs, Flores, Oleum è floribus destillatum*.
  - " Limonum—*Cortex fructûs, Oleum è fructûs expressum*.
  - " Bergamia—*Oleum è fructûs destillatum*.
  - " vulgaris—*Cortex fructûs, Oleum è floribus destillatum*.
- GUTTIFERÆ.
  - Canella alba—*Cortex*.
- RUTACEÆ.
  - Ruta graveolens—*Herba, Oleum*.
  - Barosma crenata—*Folia*.
- ROSACEÆ.
  - Rosa centifolia—*Oleum è floribus destillatum*.
- MYRTACEÆ.
  - Melaleuca minor—*Oleum Cajuputi*.
  - Caryophyllus aromaticus—*Flores nondum explicati, Oleum*.
  - Eugenia Pimenta—*Fructus, Oleum*.
- UMBELLIFERÆ.
  - Fœniculum dulce—*Fructus, Oleum*.
  - Anethum graveolens—*Fructus, Oleum*.
  - Archangelica officinalis—*Radix*.
  - Carum Carui—*Fructus, Oleum*.
  - Coriandrum sativum—*Fructus*.
  - Cuminum Cyminum—*Fructus*.
  - Daucus Carota—*Radix, Fructus*.
  - Pimpinella Anisum—*Fructus, Oleum*.
- CAPRIFOLIACEÆ.
  - Sambucus nigra—*Flores*.
- VALERIANACEÆ.
  - Valeriana sylvestris—*Radix*.
- COMPOSITÆ.
  - Inula Helenium—*Radix*.
  - Anthemis nobilis—*Flores, Oleum*.
  - Anacyclus Pyrethrum—*Radix*.
  - Artemisia Absinthium—*Herba*.
  - Tanacetum vulgare—*Herba*.
  - Arnica montana—*Flores*.

LABIATÆ.
Hyssopus officinalis—*Herba.*
Lavandula vera—*Flores, Oleum.*
Melissa officinalis—*Herba.*
Mentha piperita—*Herba, Oleum.*
" Pulegium—*Herba, Oleum.*
" viridis—*Herba, Oleum.*
Majorana hortensis—*Herba.*
Origanum vulgare—*Oleum ex herbâ.*
Rosmarinus officinalis.—*Herba, Oleum.*
Salvia officinalis—*Herba.*

MYRISTACEÆ.
Myristica officinalis—*Nux, Macis, Olea.*

LAURACEÆ.
Cinnamomum Cassia—*Cortex, Oleum.*
" Zeylonicum—*Cortex, Oleum.*
Camphora officinarum—*Camphora.*
Laurus nobilis—*Baccæ.*
Sassafras officinale—*Lignum, Oleum.*

ARISTOLOCHIACEÆ.
Aristolochia Serpentaria—*Radix.*
Asarum Europæum—*Folia.*

EUPHORBIACEÆ.
Croton Cascarillæ—*Cortex.*

PIPERACEÆ.
Piper nigrum—*Fructus.*
" longum—*Fructus.*
" Cubeba—*Fructus, Oleum.*
URTICACEÆ.
Humulus Lupulus—*Strobili, Oleum.*
Dorstenia Contrayerva—*Radix.*
CONIFERÆ.
Juniperus Sabina—*Cacumina.*
" communis—*Fructus, Oleum.*
Pinus; plurimæ species—*Oleum.*
ORCHIDACEÆ.
Vanilla aromatica—*Fructus.*
ZINGIBERACEÆ.
Zingiber officinale—*Rhizoma.*
Elettaria Cardamomum—*Semina.*
Curcuma longa—*Rhizoma.*
" Zedoaria—*Rhizoma.*
IRIDACEÆ.
Crocus sativus—*Stigmata.*
LILIACEÆ.
Allium sativum—*Bulbus.*
" Cepa—*Bulbus.*
ACORACEÆ.
Acorus Calamus—*Rhizoma, Oleum.*

Considered with reference to their chemical composition the volatile oils are of two kinds,—the sulphurated and the non-sulphurated.

a. Sulphurated volatile oils.—Of these the most important and best known are the oils obtained from alliaceous and cruciferous plants, and whose hypothetical radical is *allyle* ($All = C^6 H^5$).

These oils may be termed the *allyle oils,* to distinguish them from other sulphurated oils. They are obtained by distillation with water from the respective plants: they are heavier than water, have a very pungent fetid smell, and an acrid burning taste, and, when applied to the skin, cause redness and vesication. Their vapours cause a copious flow of tears.

The allyle oils are of two kinds: some consist of sulphuret of allyle[1] (All S), others of sulphocyanide of allyle (All Cy S). The former are obtained from Liliaceæ, the latter from Cruciferæ.

OFFICINAL ALLYLE OILS.

From Liliaceæ. (All S.)	*From Cruciferæ.*[2] (All Cy S.)
Oil of Allium sativum.	Oil of Sinapis nigra.[3]
" Cepa.	" Cochlearia Armoracia.
" Porrum.	" officinalis.

The oils (All Cy S) obtained from Cruciferæ by distillation with water do not exist ready formed in the vegetables from which they are procured, but are produced by the mutual action of substances existing in the plants, aided by water.

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[1] Assafœtida contains two volatile oils, one of which appears to be sulphuret of allyle.

[2] The volatile oils of a considerable number of cruciferous plants, besides those mentioned in the text, are sulphocyanides of allyle (see Wertheim, *Chemical Gazette,* vol. iii. pp. 177, 186, and 495; Will, *Ch. Gaz.* vol. iii. 253 and 277; Pless, *Ch. Gaz.* vol. iv. p. 252).—*Cardamine pratensis* probably contains sulphocyanide of allyle.

[3] White mustard, *sinapis alba,* does not yield the same oil as black mustard.

The oil of hops (*Humulus Lupulus*) contains sulphur; but it probably does not belong to the allyle series.

β. Non-sulphurated volatile oils.—These are of two kinds,—oxygenated and non-oxygenated.

Non-oxygenated oils are compounds of carbon and hydrogen, and their empirical formula is $C^{10} H^{8}$. The following oils belong to this section:—

Volatile oils of Coniferæ.
Oil of turpentine.
Oil of juniper.
Oil of savine.

Volatile oil of Zingiberaceæ.
Oil of cardamoms.

Volatile oils of Aurantiaceæ.
Oil of lemons.
Oil of cedro.
Oil of cedrat.
Oil of neroli (orange flower).
Oil of oranges (both bitter and sweet).

Volatile oils of Piperaceæ.
Oil of pepper.
Oil of cubebs.

Volatile oils of Myrtaceæ.
Light oil of cloves.
Light oil of allspice (?).

If they "be distilled with quicklime in vacuo, or in an atmosphere of carbonic acid, the product is absolutely inodorous: and it is impossible in this state to discriminate oil of lemons from oil of turpentine or of juniper; but, when exposed to the air, they quickly become odorous, while they absorb oxygen, becoming viscid and resinous. It would appear, therefore, as if the odour accompanied the act of oxidation, as is the case with metallic arsenic."[1]

The *oxygenated essential oils* are usually mixtures of several oils differing in volatility. To this series belong the volatile oils of the officinal Iridaceæ, Euphorbiaceæ, Lauraceæ, Myristicaceæ, Labiatæ, Compositæ, Valerianaceæ, Umbelliferæ, Myrtaceæ (the oils heavier than water), and Rosaceæ.

The non-sulphurated oils of this sub-order are frequently associated with resin: in some cases this appears to be formed by the oxidation of the volatile oil.

Some of the æthereo-oleosa, whose non-sulphurated oils have a very agreeable and fragrant odour, are employed as *perfumes;* and some of them are used for this purpose in medicine for the purpose of scenting lotions, ointments, &c. (see *ante*, pp. 2, 3, and 163).

Others are used as *condiments* or *seasoners*. At the head of these stand the *spices* (*aromata*), products of warm climates, distinguished by their agreeable, warm flavour, and, in some cases, by considerable pungency or acridity. The most important of them are cinnamon, cassia, ginger, turmeric, zedoary, nutmegs, mace, pimento, cloves, the peppers, cardamoms, saffron, and vanilla. Next to these, but inferior to them in strength and fineness of aroma, come the *sweet* and *savoury herbs*, obtained chiefly from Labiatæ and Umbelliferæ. They are cultivated in this country, and are used by the cook for soups, stews, savoury dishes, stuffing, &c. The fruits of some of the Umbelliferæ are used under the name of *seeds* by confectioners for flavouring cakes, &c. Several of the spices, and some of the herbs and umbelliferous fruits, are used by the distiller for flavouring liqueurs.

The alliaceous and cruciferous plants from which the allyle oils are obtained are used dietetically as *salads* (*acetaria*), *pot-herbs* (*olera*), and *condiments*.

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[1] Turner's *Elements of Chemistry*, edited by Baron Liebig and Dr. Gregory, 8th edit. part ii. p. 1130.

They constitute the *officinal volatile pungent stimuli* of Dr. Duncan. They are esteemed antiscorbutic.

Considered therapeutically, the æthereo-oleosa are used for several purposes, of which the most important are the following:—

1. To communicate an agreeable flavour or smell to medicinal compounds (see *ante*, pp. 2 and 3), and for the purpose of fumigation (see *ante*, p. 163).

2. As topical stimulants or acrids (see *ante*, p. 164, *et seq.*)

3. As gastro-intestinal stimulants they are employed under the denomination of stomachics, carminatives, antispasmodics, and cordials. The spices and the æthereo-oleosa obtained from Labiatæ, Umbelliferæ, and Compositæ, are frequently used for these purposes. In enfeebled or relaxed habits they are employed to assist digestion. In flatulency and spasm of the alimentary canal, especially the flatulent colic of children, they are administered as carminatives and antispasmodics. They are also used to allay colicky pains, to correct the griping qualities of some cathartics, and to check purging in mild forms of diarrhœa. For the latter purpose nutmegs are especially serviceable on account of their narcotic properties.

On account of their acrid and heating properties, spices are objectionable in inflammatory conditions of the alimentary canal, and in febrile states of system.

4. As stimulants to the cerebro-spinal system, camphor, valerian, rue, arnica, serpentary, &c., are frequently used; sometimes, under the denomination of nervines and antispasmodics, in nervous, hypochondriacal, and hysterical complaints, and in some of the spasmodic and convulsive affections of weakly subjects; sometimes to relieve nervous exhaustion in the latter stages of continued fever.

5. As stimulants to the urino-genital apparatus the coniferous æthereo-oleosa, as well as rue, buchu, &c., are used as diuretics and emmenagogues, and to modify the condition of the mucous membrane of the bladder (see *Class* VIII. *Eccritica*).

6. As sudorifics (see *Class* VIII. *Eccritica*).

SUB-ORDER β. RESINOSA. *Resinous Stimulants.* These are vegetable stimulants which owe the whole or part of their activity to resin. The following are the most important of them:—

ZYGOPHYLLACEÆ.
  Guaiacum officinale—*Lignum, Cortex, Resina.*
TEREBINTHACEÆ.
  Pistacia Lentiscus—*Resina.*
  " Terebinthus—*Terebinthina chia.*
  Boswellia thurifera—*Gummi-resina.*
  Balsamodendron Myrrha—*Gummi-resina.*
  Icica Icicariba—*Resina Elemi.*
  Canarium commune—*Resina Elemi (?).*
LEGUMINOSÆ.
  Copaiferæ plurimæ species—*Resina liquida.*
  Myrospermum peruiferum—*Balsamum.*
  " toluiferum—*Balsamum.*
UMBELLIFERÆ.
  Ferula Assafœtida—*Gummi-resina.*
  " (?) " *Gummi-resina (sagapenum).*
  Dorema Ammoniacum—*Gummi-resina.*
  Opoponax chironium—*Gummi-resina.*
  Galbanum officinale—*Gummi-resina.*

COMPOSITÆ.
  Anacyclus Pyrethrum—*Radix.*
STYRACEÆ.
  Styrax Benzoin—*Balsamum.*
  " officinale—*Balsamum.*
SOLANACEÆ.
  Capsicum annuum—*Fructus.*
THYMELACEÆ.
  Daphne Mezereum—*Radicis cortex.*
CONIFERÆ.
  Pinus palustris, " tæda, " Pinaster, " sylvestris—*Terebinthina vulgaris, Resina vulgaris.*
  Abies excelsa—*Abietis resina, Pix Abietina.*
  " balsamea—*Balsamum Canadense.*
  " picea—*Terebinthina Argentoratensis.*
  Larix europæa—*Terebinthina Veneta.*
LILIACEÆ.
  Xanthorrœa hastile—*Resina.*

Considered with respect to their chemical nature, the resinosa may be arranged in four groups, as follows:—

1. *Resinæ*, or Resins properly so called. These consist essentially of resin only. Such are guaiacum, mastic, elemi, and common resin, usually denominated rosin. To this group, also, belong the active principles of mezereon and capsicum.

2. *Oleo-resinæ*, or Oleo-resins.—These are semi-liquid or glutinous juices composed of volatile oil and resin. They are sometimes called *balsams*. Such are the various kinds of turpentines (including Canada balsam) and copaiba.

3. *Resinæ benzoicæ* vel *cinnamicæ*.—Resins which contain or yield benzoic or cinnamic acid. To these the term *balsam* has, by some, been exclusively applied. To this group belong the balsams of peru and tolu, benzoin, storax, and the resin of Xanthorrœa hastile.

4. *Gummi-resinæ*.—Gum-resins. These consist of gum and resin, usually with traces of volatile oil. The gum-resins obtained from the family Umbelliferæ,—viz. assafœtida, galbanum, sagapenum, ammoniacum, and opoponax,—contain a sulphurated volatile oil (sulphuret of allyle?), and are commonly distinguished as the *fetid gum-resins* (*gummi-resinæ fœtidæ; gummi-ferulaceæ*). The other gum-resins, which may be distinguished as *simple gum-resins*, are myrrh and olibanum.

The resinosa are all local irritants; the oleo-resinæ being the most powerful. When applied to the skin they occasion redness, and, in some cases, inflammation. When swallowed, they occasion more or less irritation of the alimentary canal, according to the nature of the agent and the dose in which it is taken; the symptoms being epigastric heat, loss of appetite, nausea, and even vomiting; and, sometimes, when the quantity swallowed is large, griping or purging.

They become absorbed, at least partially, if not wholly. Several of them have been detected in the blood by their odour. In various secretions also they have been recognized (see *ante*, pp. 101, 102, 110).

After their absorption they operate as stimulants on the general system; quickening the pulse, increasing the heat of the skin, and producing a kind of febrile condition. They exercise a stimulant influence over the secreting organs; especially the kidneys, the mucous surfaces, and the skin. The effect of the oleo-resins on the urinary organs is manifested by uneasiness in the region of the kidneys, increased desire of passing the urine, heat in the urethra, and sometimes strangury and bloody urine. Under the influence even of small doses the urine acquires a remarkable odour; which, when any of the turpentines have been taken, is that of violets. The mucous membranes generally are stimulated, and, in fluxes, the secretions are frequently diminished. By repeated use they sometimes cause a cutaneous eruption.

The central organs of the nervous system are affected by several of them. Thus oil of turpentine in large doses disorders the cerebral functions. The fetid gums affect the reflex-spinal functions and act as antispasmodics (see *ante*, pp. 207 and 208).

The following are some of the more important uses of the resinous stimulants:—

1. Some are employed as local irritants or acrids (see pp. 164—166).

2. The oleo-resins and olibanum are principally employed in medicine to

relieve fluxes, especially of the urino-genital mucous membrane. Thus they are employed, and with great benefit, in gonorrhœa, leucorrhœa, gleet, and chronic catarrh of the bladder. In chronic pulmonary catarrhs they are sometimes advantageously employed; but not unfrequently prove injurious, as Dr. Fothergill[1] has shown.

The balsams (benzoic and cinnamic resins) are also used as stimulants to the mucous membrane lining the air passages. MM. Trousseau and Pidoux[2] assert, from their own experience, that "there are few substances in the materia medica so powerful in combating chronic pulmonary catarrhs and old laryngeal inflammations as the balsams." In chronic inflammation of the larynx, whether accompanied or not by ulceration, balsamic fumigations are more serviceable than the internal exhibition of the balsams. The air of the patient's chamber may be impregnated with balsamic vapours by placing a little benzoin or tolu on some live coals, and allowing the vapour to escape into the room; or the patient may inhale the vapour of boiling water to which a drachm or two of the balsams have been added.

3. The fetid gum-resins have been principally, and most successfully, employed in hysteria, flatulent colic, and spasmodic asthma. Their antispasmodic influence has been before alluded to (see *ante*, pp. 207—208).

Myrrh does not possess the antispasmodic power of the fetid gums, but approaches nearer to the tonics.

4. Several of the resinosa are used as emmenagogues, diuretics, and sudorifics (see *Class* VIII. *Eccritica*).

5. Oil of turpentine has been used in neuralgia, against tape-worm, in puerperal peritonitis, and in other cases to be mentioned hereafter.

6. The liquid balsams (of styrax and peru) are sometimes applied to chronic indolent ulcers to allay pain, to improve the quality of the secreted matter (*detergents*), and to promote cicatrization (*epuloties* or *cicatrisantia*).

SUB-ORDER γ. AMMONIACALIA ET EMPYREUMATICA.—This sub-order contains ammoniacal stimulants (ammonia and its carbonates) and the empyreumatic oils and resins.

The following are the more important substances of this sub-order:—

AMMONIACALIA.

Ammonia.
Liquor ammoniæ.
Ammoniæ carbonas.
Ammoniæ sesquicarbonas.
Ammoniæ bicarbonas.

EMPYREUMATICA.

α. *Olea ætherea.*
  Oleum animale æthereum seu Dippelii.
  Oleum cornu cervi rectificatum.
  Oleum succini rectificatum.
  Creasoton.
  Oleum petræ (petroleum rectificatum).
β. *Oleo-resinæ.*
  Pix liquida—*Aqua picis.*
γ. *Resinæ.*
  Pix nigra.

AMMONIACALIA ET EMPYREUMATICA.

Liquor ammoniæ carbonatis empyreumaticus (v. *spiritus cornu cervi*).

Both ammoniacalia and empyreumatica are obtained by the dry distillation of substances of an organic origin. In some cases (as in the distillation of bones, hartshorn, and coal) both classes of compounds are simultaneously developed.

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[1] *Medical Observations and Inquiries*, vol. iv. p. 231.

[2] *Traité de Thérapeutique*, t. i. p. 467.

For this reason, as well as that the two classes agree in some respects in their medicinal properties, and are often associated for medicinal use (ex. *spiritus cornu cervi*, and *tinctura ammoniæ compositæ*, Ph. Lond.), I have thought it expedient to group them together.

The general chemical nature of the substances of this sub-order is shewn in the table. The chemical properties of the individual agents will be noticed hereafter.

The ammoniacalia and empyreumatica are powerful local irritants, several of them (*e. g.* ammonia and creosote) acting chemically (see *ante*, pp. 94, 176, and 177).

When swallowed, some of them undergo chemical change before their absorption; as ammonia (see *ante*, pp. 89 and 177), and creosote. The latter probably combines with albumen.

It can scarcely be doubted that all the agents of this sub-order become absorbed. Dippel's oil has been detected in the blood and in the breath (see *ante*, pp. 101—102).

The stimulants of this sub-order powerfully influence the functions of the nervous system, whose energy and activity they exalt. According to Vogt,[1] the more volatile the remedy, the more it increases the *activity* of the nervous functions, and the more fixed the more it raises their *energy*. Thus, according to the same writer, the preparations of ammonia raise the activity more than the energy of these functions; the empyreumatic oils somewhat less.

In some disordered conditions of the reflex-spinal functions, they allay spasmodic action (see *ante*, pp. 207—8). In poisonous doses, they rapidly destroy life; acting in the twofold capacity of irritants to the stomach and bowels, and poisons to the nervous system. In moderate doses, they act as stimulants to the mucous surfaces, the skin, and other secreting organs.

The effects of the substances composing this sub-order are very quickly produced, and soon disappear. Consequently, these remedies are adapted to urgent and acute cases, when the danger is imminent, and an immediate effect desired: for the same reason they require to be frequently repeated, in order to keep up their effects. From their exciting operation, they are indicated in cases of debility and sinking of the vital powers, and in spasmodic diseases.

The following are some of the cases for which they are employed:—

1. As topical stimulants or acrids.
2. As topical applications in skin diseases; such as porrigo, lupus, &c.
3. As stimulants to the heart, blood-vessels, and nervous system, in syncope, in exhaustion from low fevers, or other causes, in collapse, as of cholera, &c.
4. As antispasmodics in hysteria, epilepsy, and angina pectoris.
5. As anthelmintics, especially for tænia.
6. Some of them have been used to allay vomiting, to check the excretion of sugar in diabetes, and to relieve obstinate chronic rheumatism.

SUB-ORDER δ. EXCRETA ANIMALIA.—Animal excretions used as stimulants.

RODENTIA.	RUMINANTIA.
Castor Fiber—*Castoreum*.	Moschus moschiferus—*Moschus*.

These substances are reputed stimulants and antispasmodics. After the internal use of musk, the odour of this substance has been detected in the blood and in the cutaneous transpiration (see *ante*, pp. 101 and 102). The odorous emanations of musk produce, in some sensitive constitutions, (see p. 3) headache and even fainting. Both musk and castoreum are employed in spasmodic affections. Musk is also used in low fevers and retrocedent gout; castoreum in nervous complaints and as a stimulant to the uterus.

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[1] *Lehrbuch der Pharmakodynamik*, Bd. i. S. 186, 2te Aufl. Giessen, 1828.

SUB-ORDER ε. PHOSPHORUS.—Phosphorus requires to be placed in a separate sub-order of stimulants, on account of the peculiarity both of its chemical properties and physiological effects.

When swallowed it operates as an irritant and caustic (see p. 93). It becomes absorbed and communicates an alliaceous odour to the breath. After its absorption it acts as a stimulant to the nervous, vascular, and secreting organs. It excites the mental faculties and the sexual feelings, raises the temperature of the skin, increases the frequency of the pulse, and promotes the secretions. In large doses it operates as an irritant poison, becomes absorbed, and produces convulsions, insensibility, and death.

The workmen engaged in the manufacture of lucifer matches (especially the dippers) are occasionally liable to necrosis of the jaw-bone.[1] Dr. von Bibra[2] thinks that the deleterious effects are due to hypo-phosphorous acid contained in the atmosphere of the manufactory.

Phosphorus is administered as a stimulant to the nervous centres in convulsive and old paralytic cases, and in lower fevers; as an aphrodisiac; and as a cutaneous stimulant in some exanthematous diseases in which the eruption has receded from the skin.

SUB-ORDER ζ. SPIRITUOSA ET ÆTHEREA. *Alcoholica.*—Ardent spirits, wine, beer, and the ethers, are the agents composing this sub-order, which is identical with the Methystica, a group of the Phrenica, whose effects have been already noticed (see *ante*, p. 200).

The physical and chemical action of some of the agents of this sub-order have been before referred to (see *ante*, pp. 87, 88, 93, 94, 95, and 109).

They are employed as powerful and diffusible stimulants in failure of the vital powers. In delirium from exhaustion and inanition they are invaluable; but in delirium from congestion or inflammation of the brain they are injurious.

ORDER 2. SEDANTIA; *Sedativa; Deprimentia.*—By the term sedative I understand an agent which directly diminishes the force of the action of the heart and other organs by repressing the nervous influence.

Sedatives have been confounded with both stimulants and narcotics. The effect of a sedative should be distinguished from the exhaustion which results from over-stimulation: the former is primary and direct; the latter is secondary and indirect. Several of the substances called narcotics act also as sedatives: but all sedatives are not narcotics; for example, emetic tartar. Narcotics may be advantageously combined with either stimulants or sedatives; as opium with brandy or ammonia, or opium with digitalis or emetic tartar. But stimulants and sedatives, as brandy and digitalis, or ammonia and emetic tartar, cannot be expected to produce any useful combined effect.

The following are the substances most frequently employed as sedatives:—

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[1] In these cases, Dr. Letheby (*London Medical Gazette*, vol. iv. N. S. p. 153,) found an unusual quantity of phosphoric acid in the urine.

[2] *Die Krankheiten der Arbeiter in den Phosphorzündholzfabriken, ins besondere das Leiden der Kieferknochen durch Phosphordampfe. Vom chemischphysiologischen, medicinischchirurgischen und medicinischpolizeilichen Standpunkte.* Bearbeitet von Dr. F. E. von Bibra und Dr. L. Geist. Erlangen, 1847. (Reviewed in the *British and Foreign Medico-Chirurgical Review*, No. II. April 1848, p. 446.)

ORGANIC.

RANUNCULACEÆ.
Aconitum Napellus—*Radix.*
PAPAVERACEÆ.
Papaver somniferum — *Opium, Morphia.*
TERNSTRŒMIACEÆ.
Thea Bohea—*Folia.*
" viridis—*Folia.*
AMYGDALEÆ.
Amygdalus communis —*Amygdalæ amaræ.*
Cerasus Lauro-cerasus—*Folia.*
UMBELLIFERÆ.
Conium maculatum—*Folia, Fructus.*
SOLANACEÆ.
Hyoscyamus niger—*Folia.*
Atropa Belladonna—*Folia.*
Nicotiana Tabacum—*Folia.*
SCROPHULARIACEÆ.
Digitalis purpurea—*Folia.*
MELANTHACEÆ.
Colchicum autumnale—*Cormus.*

Acidum hydrocyanicum.

INORGANIC.

Antimonii Potassio-Tartras.

The topical action of most of these agents has been already noticed (see pp. 165, 184, 198).

After the absorption of these agents, or their active principles, into the blood, they operate as sedatives to the vascular system; that is, they diminish the force of the heart's action, and reduce the strength, and sometimes the frequency also, of the pulse; but diminution of the frequency of the pulse is neither a constant nor a necessary effect of a sedative.

> "Digitalis and other sedatives sometimes make the pulse quicker than it was before: but every person who has bled a few patients must have observed that the pulse becomes quicker as the patient grows faint. Mere increased frequency of pulse is not, therefore, a proof [that digitalis at first produces a stimulant effect], as no person will call blood-letting to syncope a stimulant."[1]

Digitalis frequently causes an intermittent pulse. In excessive doses some of the sedatives (*e. g.* tobacco, aconite, and digitalis) destroy life by causing paralytic syncope (see *ante*, p. 216).

The effect of sedatives on the other functions is not uniform. Several (*e. g.* emetic tartar and tobacco) produce excessive nausea, depression, and exhaustion. Some (*e. g.* colchicum and emetic tartar) purge; others (*e. g.* morphia) cause constipation.

The effects of aconite and hyoscyamus have been already alluded to (see *ante*, pp. 202, 205). Digitalis acts as a diuretic.

The manner in which some of these agents cause death has been before noticed (see *ante*, p. 214).

Sedatives are employed to reduce the force of the vascular system in acute inflammation and inflammatory fever. For this purpose emetic tartar, or sometimes colchicum, is used. Also to tranquillize the action of the heart, and to allay the excessive irritability of the nervous system, when not dependent on anæmia or extreme debility. For this purpose the narcotic sedatives are frequently used. Likewise to control irregularities of the circulation. To allay palpitation, hydrocyanic acid, digitalis, and aconite, are sometimes used with advantage. Belladonna plaster is frequently employed for the same purpose.

2. *Affecting the alimentary canal.*—The ganglionics which affect the alimentary canal are of three kinds:—

a. Some affect the movements of the alimentary canal. Those which promote and quicken them are denominated purgatives, and will be noticed hereafter (see *Class* VIII. *Eccritica*). Others lessen the peristaltic movements and relieve spasm (see *Paralytica*, p. 212). Of these the most powerful is opium (see *Meconica*, p. 201).

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[1] *First Principles of Medicine*, by Arch.^{d} Billing, M.D. A.M. p. 81, 4th edit. 1841.

β. Some relieve pain in the alimentary canal (see *Anæsthetica*, p. 203).

γ. Some affect the secretions of the alimentary canal (see *Class* VIII. *Eccritica*).

Class VII. *Cœliaca*. Medicines acting on the Digestive Organs.

Medicines which act on the digestive organs may be termed *cœliaca* (κοιλιακά; from κοιλία, *the belly*). They may be divided into five orders,—those affecting the alimentary canal (*enterica*); those affecting the salivary glands (*sialica*); those affecting the liver (*hepatica*); those affecting the spleen (*splenica*); and those affecting the pancreas (*pancreatica*).

ORDER 1. ENTERICA (ἐντερικά; from ἔντερον, *the bowels*).—Agents which affect the alimentary canal. Most of the agents belonging to this order either have been already noticed or will be more conveniently considered hereafter under other heads.

α. The enterica employed as *stomachics* and *carminatives* have been before noticed under the order *Stimulantia* (see *ante*, p. 218).

β. The enterica which are used to allay thirst (*adipsa*) have been already considered under the order *Spanæmica* (see *ante*, p. 170).

γ. The enterica which are administered to promote the appetite belong to the *tonica* (see *ante*, p. 206).

δ. The enterica which affect the movements of the alimentary canal have already been incidentally alluded to (see *ante*, p. 213); but, as most of them also affect the secretions of the gastro-intestinal surface, they will be specially noticed hereafter under the class *Eccritica*.

ε. The enterica which are employed to allay pain of the alimentary canal are the *anæsthetica* before noticed (see p. 203).

ζ. The enterica which affect the secretions of the gastro-intestinal mucous membrane will be hereafter described (see *Class* VIII. *Eccritica*).

η. Some enterica destroy, counteract, neutralize, or expel morbific substances contained in the alimentary canal. To this division belong the agents called *antidotes*, employed in cases of poisoning (see *ante*, pp. 154 and 159); chemical agents administered to relieve dyspeptic acidity or alkalinity of the gastro-intestinal fluids (see *ante*, pp. 174 and 178); and *anthelmintics*, employed to expel intestinal worms. Of these the latter alone require special notice here.

SUB-ORDER. ANTHELMINTHICA (from ἀντί, *against*, and ἕλμινς, *a worm*); *Helminthagoga*; *Vermifuga* (from *vermis*, a worm, and *fugo*, I expel). Anthelmintics are agents which cause the destruction or expulsion of intestinal worms. There are five entozoa inhabiting the human intestinal canal, and to which the name of intestinal worms is given. Of these, three species possess an alimentary canal, and are, therefore, called hollow worms or *Cœlelmintha* (from κοῖλος, *hollow*, and ἕλμινς, *a worm*), while the other two have no true abdominal cavity, and are in consequence called solid worms or *Sterelmintha* (from στερεός, *solid*, and ἕλμινς, *a worm*).

CŒLELMINTHA.

Les intestinaux cavitaires (*Cuvier*).
Entozoa nematoïdea (*Rudolphi*).

1. *Tricocephalus dispar*, or Long Thread-Worm. Found in the cæcum and large intestine.
2. *Ascaris lumbricoides*, or Large Round-Worm. Found in the small intestine.
3. *Ascaris*[1] *vermicularis*, or Small Thread-Worm. Found in the rectum.

STERELMINTHA.

Les intestinaux parenchymateux (*Cuvier*).

1. *Tænia Solium*, or Common Tape-Worm. Found in the small intestine of the English, Dutch, and Germans.
2. *Bothriocephalus latus*, or Broad Tape-Worm. Found in the small intestine of the Swiss and Russians.

In English medical practice three only of these come under our notice for treatment; for it does not appear that the long thread-worm excites any morbid symptoms, and the broad tape-worm does not inhabit the bowels of our countrymen.

A considerable number of substances have been considered to possess anthelmintic properties. The following is a list of the chief of them:—

VEGETABLE.

RANUNCULACEÆ.
Helleborus niger—*Radix.*
Helleborus fœtidus—*Folia.*
GUTTIFERÆ.
Hebradendron —— (?) —*Cambogiæ gummi-resina.*
MELIACEÆ.
Melia Azedarach—*Cortex radicis.*
RUTACEÆ.
Ruta graveolens—*Folia, oleum.*
SIMARUBACEÆ.
Picræna excelsa—*Lignum.*
LEGUMINOSÆ.
Andira inermis—*Cortex* (*Geoffroyæ*).
Mucuna pruriens—*Leguminum setæ.*
Cassia; plurimæ species—*Sennæ folia.*
AMYGDALEÆ.
Persica vulgaris—*Folia.*
MYRTACEÆ.
Melaleuca minor—*Oleum* (*Cajuputi*).
CUCURBITACEÆ.
Cucumis Colocynthis—*Fructus pulpa.*
UMBELLIFERÆ.
Ferula Assafœtida—*Gummi-resina.*
VALERIANACEÆ.
Valeriana sylvestris—*Radix.*
COMPOSITÆ.
Tanacetum vulgare—*Herba, semina, flores, oleum.*
Artemisia Absinthium—*Herba, oleum.*
Artemisia Santonicum—*Cacumina (semen santonicum).*
OLEACEÆ.
Olea Europæa—*Oleum.*
SPIGELIACEÆ.
Spigelia Marilandica—*Radix.*
CONVOLVULACEÆ.
Convolvulus Scammonia—*Gummi-resina.*
Ipomæa Purga—*Radix* (*Jalapæ*).
SOLANACEÆ.
Nicotiana Tabacum—*Folia.*
CHENOPODIACEÆ.
Chenopodium anthelminticum—*Fructus.*
LAURACEÆ.
Camphora officinarum—*Camphora.*
EUPHORBIACEÆ.
Ricinus communis—*Oleum.*
Croton Tiglium—*Oleum.*
JUGLANDACEÆ.
Juglans regia—*Cortex nucum.*
CONIFERÆ.
Pinus; plurimæ species—*Oleum Terebinthinæ.*
Juniperus Sabina—*Folia, oleum.*
LILIACEÆ.
Allium sativum—*Bulbus.*
Aloë; plurimæ species—*Succus concretus.*
MELANTHACEÆ.
Asagræa officinalis—*Semina (Cebadilla).*
FILICES.
Nephrodium Filix mas—*Rhizoma, oleum.*
ALGÆ.
Gigartina Helminthocorton.

Acetum.

ANIMAL.

Oleum animale Dippelii.
Oleum Cornu cervi empyreumaticum.

MINERAL.

Hydrargyrum.
Hydrargyri bichloridum.
Hydrargyri chloridum.
Stannum—*Pulvis.*
Ferrum—*Limatura.*
Ferri sulphas.
Ferri sesquichloridum.
Acidum arseniosum.
Antimonii potassio-tartras.
Calx—*Aqua calcis.*
Sodii chloridum.
Potassæ sulphas.
Aqua (frigida).
Petroleum.

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[1] Those Helminthologists who have failed to detect in this animal the three valvular papillæ characteristic of the genus *Ascaris*, refer the species to the genus *Oxyuris*, (see the article *Entozoa*, by Professor Owen, in the *Cyclopædia of Anatomy and Physiology*).

Considered with regard to their *modus operandi*, anthelmintics are of two kinds:—

1. Some act obnoxiously on intestinal worms—destroying or injuring them. These are the anthelmintics properly so called; the anthelmintic specifics; or the *vermicides* of some authors. Some of these agents, as powdered tin and cowhage, operate mechanically (see *ante*, p. 155); others act either chemically or dynamically, as oil of turpentine.

2. Some agents prove anthelmintic in consequence of their operation on the bowels: these are the cathartic anthelmintics or *vermifuges;* such as calomel, jalap, scammony, and gamboge.

Some writers admit another class of anthelmintics, namely agents "which increase the tone of the digestive organs, and thereby obviate that condition of the stomach and bowels which appears to favour the generation and nourishment of these animals."[1]

The best anthelmintic prophylactics are—wholesome food and the use of purgatives, if the bowels be costive, and of bitter or ferruginous tonics if debility exist.

The circumstances which favour or check the production of intestinal worms are imperfectly understood; and the assumption that their formation is referable to a debilitated state of the alimentary canal is entirely hypothetical. Some persons appear to be constitutionally disposed to their production. Negroes seem to be more liable to them than the white races.

In the treatment of helminthiasis it is generally advisable to employ both cathartics and the anthelmintic specifics. The first aid the expulsion of the worms in at least two ways;—mechanically, and by preventing the accumulation of intestinal mucus. Some cathartics may also act as poisons to the worms.

The following was Bremser's favourite anthelmintic, and which he states that he used for many years with the greatest success against all species of intestinal worms:—

℞ Seminum Santonici (vel seminum seu florum Tanaceti) contusorum	℥ss.
Pulveris Valerianæ	ʒij.
Pulveris Jalapæ	ʒjss.—ʒij.
Potassæ Sulphatis	ʒjss.—ʒij.
Oxymellis Scillæ	q. s. ut fiat electuarium.

Two or three teaspoonfuls to be taken daily.

Anthelmintics are administered both by the mouth and by the rectum. When the worms are contained in the small intestine (as the large round worm and the tape-worm) they should be given by the mouth; but for worms in the rectum (as the small thread-worm) anthelmintic enemata are preferable. "To introduce at one end of a tube, several yards long, substances which are intended to act upon animals that live quite at its other end, would be a very round-about course."[2]

Each kind of parasite has been supposed to require its particular mode of treatment. It may be useful, therefore, to notice successively the remedies which have gained the most repute for each species of worms.

1. *Treatment for Thread-Worm* (Ascaris vermicularis).—As these animals usually inhabit the rectum, they are best treated by clysters.[3] These may consist of ice-cold water, vinegar and water, salt and water, infusion of quassia with or without common salt in solution, lime water, solution of sulphate of

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[1] Eberle, *A Treatise of the Materia Medica*, 2d edit. vol. i. p. 147. 1824.

[2] Watson's *Lectures on the Principles and Practice of Physic*, vol. ii. p. 505.

[3] "Thread-worms may be scooped out of the rectum with the finger. Old women fish for them with a piece of fat meat, or candle, wherewith the entangled worms are drawn out of the bowel" (Watson, *op. cit.*)

iron, solution of sesquichloride of iron (half an ounce of the tincture of sesquichloride of iron to half a pint of water), decoction of aloes, assafœtida mixture, castor oil (in gruel or any other simple vehicle), oil of turpentine, or infusion of senna.

The preceding are safe enemata. Injections of tobacco infusion, and solutions of arsenic and corrosive sublimate, have been recommended; but they are highly dangerous and, I believe, unnecessary.

A solution of a table-spoonful of common salt in cold water or in infusion of quassia usually proves a most effective anthelmintic enema. Where this fails a turpentine clyster may be had recourse to. For children, one to four drachms, for adults one or two ounces, of this oil may be administered mixed with gruel.

The intolerable itching which thread-worms give rise to is frequently allayed by enemata of olive oil. Dr. Watson states that it may be quieted by applying a towel, wetted with cold water, to the fundament, while in bed.

Brisk cathartics should be from time to time administered by the mouth.

The thread-worm is sometimes found in the cæcum. In this case it is obvious that enemata must fail in removing them. We must then administer our remedies by the mouth. Besides the use of cathartics, bitters (quassia, semen santonicum, tansy, &c.) and chalybeates (sulphate or tincture of sesquichloride of iron), or, where these fail, oil of turpentine may be had recourse to.

2. *Treatment for the Long Thread-Worm* (Tricocephalus dispar).—This worm is not known to produce any morbid symptoms; and remedies for it, therefore, are not likely to be required. Should its presence in the bowels be unequivocally ascertained (as by the patient's voiding some of these entozoa by stool) the same treatment may be adopted as for the small thread-worm when seated in the cæcum.

3. *Treatment for the Long Round Worm* (Ascaris lumbricoides).—This species of parasite is best treated by active evacuants, and in the intervals of their use by some of the specific anthelmintics.

A mixture of calomel and jalap forms a good purgative. Where calomel is objectionable, a mixture of jalap, scammony, and gamboge, may be substituted; or, in some cases, a mixture of jalap and rhubarb. I have frequently found the compound infusion of senna, with an occasional dose of calomel, very effectual.

Bradley[1] recommends the use of antimonial or ipecacuanha emetics. When the worms are contained in the stomach or upper part of the small intestines, the use of emetics undoubtedly proves very serviceable.

The specific anthelmintics which have been recommended for this species of worm are very numerous, though few of them, I suspect, are employed in this country at the present time. Tin powder, cowhage, pink root (*Spigelia*), and cabbage tree bark (*Andira*), have been much celebrated. The mode of using them will be hereafter noticed. Bitters (as quassia) and chalybeates (sulphate and tincture of sesquichloride of iron) are frequently employed, and with benefit. Oil of turpentine sometimes proves effective, but less frequently so than in tape-worm. For adults Bradley recommends bichloride of mercury and arsenious acid. Assafœtida, garlic, camphor, and fetid hellebore, are other remedies which have been employed.

4. *Treatment for Tape-Worm* (Tænia Solium and Bothriocephalus latus).—For the tape-worm we use a combination of purgatives and vermicides.

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[1] *A Treatise on Worms*, by T. Bradley, M.D. Lond. 1813.

The most successful remedy for tape-worm is oil of turpentine. It should be given in full doses: for an adult from six drachms to an ounce and a half; for a child from half a drachm to two or three drachms. It should be given so that it may pass through the bowels rapidly without becoming absorbed; and thus, by coming in contact with the worm, destroy it. To fulfil these objects it should be taken in the morning fasting, and, to ensure its purgative effect, an equal quantity of castor oil should be given, either in conjunction with it or within a few hours after it.

The objections to the use of oil of turpentine are—its nauseous flavour, its being apt to cause vomiting, and the brain disorder (a kind of intoxication) and irritation of the urinary organs which it sometimes excites. I have known it to produce bloody urine for several days after its employment.

Where the oil of turpentine fails, or where, from the disagreeable character of its effects, its use cannot be persevered in, other anthelmintics must be resorted to.

Male fern rhizome (Madame Nouffer's specific), cevadilla, which Schmucher considered to be infallible, the bark of the root of the pomegranate, tin filings, walnut shells, petroleum, and Chabert's empyreumatic oil, are celebrated anthelmintics for this species of intestinal worm.

Chabert's empyreumatic oil (*oleum empyreumaticum Chaberti*) is prepared by mixing one part of the empyreumatic oil of hartshorn with three parts of oil of turpentine, and submitting the mixture to distillation in a glass retort until three-fourths have passed over. The dose of the distilled product is two tea-spoonfuls in water night and morning. This remedy is to be continued until four or five, or even six or seven, ounces have been taken;—a cathartic being from time to time exhibited.

ORDER 2. HEPATICA (ἡπατικά; from ἧπαρ, *the liver*). Medicines which affect the liver and its appendages.—These agents either have been already noticed or will more conveniently be considered hereafter.

α. The hepatica which affect the secretion or excretion of bile will be noticed hereafter (see *Class* VIII. *Eccritica*).

β. The hepatica which relieve pain of the liver, gall-bladder or gall-ducts, are the *anæsthetica* before mentioned (see p. 203). Opium or morphia is the only remedy to be relied on.

γ. The hepatica employed to relieve spasm of the gall-ducts, as in the passage of biliary calculi, are the *paralytica* already noticed (see p. 212). Opium or morphia is our sheet-anchor.

δ. The hepatica administered with the view of modifying the nutrition of the liver, and thereby of relieving enlargements and other organic maladies of this organ, are the *spanæmica resolventia* which have been before noticed (see p. 175).

ORDER 3. SPLENICA (σπληνικά; from σπλήν, *the spleen*). Medicines which affect the spleen.

The number of medicinal agents which appear to exercise a specific influence over the spleen are few in number. The chief are the *chalybeates* and *quina*, and to these, perhaps, should be added *iodine*, *bromine*, and *mercurials*.

The influence of these agents over the spleen is inferred chiefly from the effects which they have been observed to produce in simple enlargement of the spleen. The beneficial effects of the chalybeates in these cases have been before alluded to (see *ante*, p. 193). According to Piorry[1] quina diminishes the volume of the spleen, and in this way cures ague.

According to Piorry the spleen is enlarged in every ague, whatever the type (whether quotidian, tertian, or quartan); and the augmentation is larger during the paroxysm than in the intermission. The salts of quina diminish the volume of the spleen, and cure ague; they are, therefore, febrifuges *par excellence*. The more soluble they are, the more rapidly do they act; and the larger the dose, the more marked are their effects on the spleen. Their action on this organ, however, is over in about half an hour after their use; and their curative power, as febrifuges, is in proportion to their effect on the spleen. M. Piorry states that he has been enabled to ascertain these circumstances by means of mediate percussion of the spleen before and after the use of quina in agues: his observations, however, have not been confirmed by others.

The effects of iodine and bromine in enlargement of the spleen have been already alluded to (see *ante*, p. 182—183). With regard to the effect of mercury on the spleen, Dr. Abercrombie[2] observes that "it is now generally admitted that, in the treatment of enlarged spleen, mercury is uniformly and highly injurious, producing mortification of the mouth and rapid failure of the strength."

The *spleen powder* and *spleen mixture*, used in Bengal in enlargements of the spleen, are combinations of rhubarb, jalap, scammony, and cream of tartar, with calumba powder and sulphate of iron, taken three times a day, in such doses as to keep up regular but moderate purging. About twenty days are stated by Mr. Twining[3] as the period which is generally required for reducing by this treatment a very considerable tumefaction of the spleen, if the case has been recent. Some persons employ nitric acid with regular aloetic purges.

ORDER 4. SIALICA ET PANCREATICA.—Medicines which affect the salivary glands are denominated *sialica* (σιαλικά; from σίαλον, *the saliva*); while those which affect the pancreas are termed *pancreatica* (from πάγκρεας, *the pancreas*). It is probable, however, that medicinal agents which affect the former also influence the latter organ.

As these agents are employed only for influencing the secretions of these organs, they will be noticed hereafter (see *Class* VIII. *Eccritica*).

Class VIII. *Eccritica*. Medicines acting on the Excernent System.

Medicines which affect the functions of the excernent system are termed *eccritica* (ἐκκριτικά; from ἔκκρισις, *secretion*).

By their influence over the process of secretion, they may affect the quantity (either increasing or diminishing it), or the quality, or both, of the secreted product. Accordingly, the eccritica are employed in medicine for the threefold purpose of augmenting, lessening, or altering the secretions.

1. *Augmenting secretion.*

(Evacuantia.)

In most cases the influence of the eccritica which augment secretion is topical; in some cases, perhaps, it may be remote.

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[1] *Traité de Médecine pratique*, t. vi. p. 123. Paris, 1845.

[2] *Pathological and Practical Researches on Diseases of the Stomach, the Intestinal Canal, the Liver, and other Diseases of the Abdomen*, p. 412, 2d edit. Edinb. 1830.

[3] *Transactions of the Medical and Physical Society of Calcutta*, vol. iii. p. 351.

Their topical influence is direct in the case of masticatories, errhines, and cathartics which are applied immediately to the secreting organ. It is indirect in the case of diuretics, expectorants, and sudorifics, whose active principles are absorbed by the parts to which they are applied, and carried by the blood to the secreting organs (see *ante*, p. 110).

In some cases, perhaps, the influence of an evacuant over a secreting organ may be remote; that is, may be exercised through the agency of the nerves.

The evacuating eccritica are used for various purposes, of which the following are the most important:—

α. To restore the natural secretion of a part when its diminution or stoppage results from torpor or deficient vascular activity of the secreting organ.

β. To augment the natural secretion of a part, and thereby to diminish the quantity of circulating fluid (see *ante*, p. 169).

γ. To augment the natural secretion of a part, and thereby to promote absorption—as in dropsy.

δ. To augment the secretion of one part, and thereby to lessen the secretion of some other part[1] (see *ante*, pp. 125—126.)

ε. To augment the secretion of an organ, and thereby to relieve local determinations of blood to remote parts; as when we administer purgatives to relieve determination of blood to the brain (see *ante*, pp. 124—125).

ζ. To promote secretion, and thereby to favour the subsidence of diseases whose natural termination is by increased secretion.

η. To produce exhaustion (the secondary effect of evacuants), and thereby to act as antiphlogistics.

ORDER 1. ERRHINA (ἔρρινα; from ἐν, *in*, and ῥὶν, *the nose*).—Medicines which are introduced into the nose, usually for the purpose of producing an increased discharge of nasal mucus, are called *errhines*. When they are employed to excite sneezing they are termed *sternutatories* (*sternutatoria*; from *sternuo*, I sneeze) or *ptarmics* (*ptarmica*; πταρμικά, from πταίρω, *I sneeze*).

Most foreign matters, especially acrid substances, when applied to the membrane lining the nostrils, provoke an increased mucous secretion; and, when snuffed up in the form of powder, usually act as sternutatories. The following are the officinal substances used as errhines:—

1. VEGETABLE.

SOLANEÆ.
- Nicotiana Tabacum—*Folia*.

LABIATÆ.
- Hyssopus officinalis—*Herba*.
- Lavandula vera—*Flores*.
- Marrubium vulgare—*Herba*.
- Melissa officinalis—*Herba*.
- Mentha Pulegium—*Herba*.
- " viridis—*Herba*.
- " piperita—*Herba*.
- Origanum Majorana—*Herba*.
- " vulgare—*Herba*.
- Rosmarinus officinalis—*Herba*.
- Salvia officinalis—*Herba*.
- Teucrium Chamædrys—*Herba*.
- " Marum—*Herba*.

ARISTOLOCHIÆ.
- Asarum Europæum—*Herba*.

EUPHORBIACEÆ.
- Euphorbia —— (?)—*Resina*.

MELANTHACEÆ.
- Veratrum album—*Cormus*.

GRAMINACEÆ.
- Saccharum officinarum—*Saccharum*.

2. INORGANIC.

Sodii chloridum. | Ammonii chloridum. | Hydrargyri subsulphas.

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[1] "Since all secretions, inasmuch as they extract certain ingredients from the blood, produce a change in its composition, no one secretion can be altered in quantity or quality without disturbing the balance which exists between all in their action on the blood; hence, the increase of one secretion gives rise to the diminution of another." (Müller's *Physiology*, by Baly, vol. i. p. 473).

Errhines are local irritants: some of them act mechanically, others chemically or dynamically.

Some medicines, as iodide of potassium, when administered by the mouth, become absorbed, and subsequently augment the nasal secretion. Such agents are not usually called errhines, because they are not applied directly to the pituitary membrane.

Errhines cause augmented secretion of nasal mucus, frequently excite sneezing, and, by long-continued use (as in the case of snuff), thicken the mucous membrane, blunt the sense of smell, and alter the tone of the voice.

Sneezing is a reflex-spinal act (see *ante*, p. 213). The incident or excitor nerve, by which the impression is conveyed to the nervous centre, is the nasal branch of the trifacial.

By repeated use errhines lose their power of exciting sneezing: at least this is well known to be the case with regard to snuff.

Dr. Hall[1] states that "actual sneezing may frequently be prevented, after the inspiration by which it is usually preceded has occurred, by forcibly rubbing the end of the nose."

Absorption readily takes place from the pituitary membrane. I have several times experienced the constitutional effects of tobacco (such as nausea, giddiness, depression of the muscular power, and disorder of the mental functions), from the use of the moist snuffs (*rappees*), especially Barbary snuff.

Considered with regard to their modus operandi, errhines may be divided into two principal groups:—

1. Those which act mechanically, as sugar.
2. Those which act chemically or dynamically as well as mechanically. This group includes the aromatic errhines of the natural order Labiatæ; the acrid errhines, such as euphorbium, veratrum, and asarum (the most powerful errhines of the order); the sedative errhine, tobacco; and, lastly, the inorganic errhines.

Errhines have been principally employed to relieve chronic affections of the eyes, face, and brain; for example, chronic ophthalmia, amaurosis, headache, &c. They can only be useful on the principle of counter-irritation (see *ante*, p. 123). In syphilitic affections of the nose, and where there is a disposition to nasal polypus, the frequent use of errhines may perhaps be injurious.

Schwilgué[2] enumerates the following purposes for which sneezing is excited:—to excite respiration when this function is suspended; to promote the expulsion of foreign bodies accidentally introduced into the air-passages; to occasion a general shock at the commencement of dangerous diseases which we wish at once to suppress; to augment the secretion of nasal mucus and of tears; to favour the excretion of mucus collected in the nasal sinuses; to exalt the action of the encephalon, of the senses, of the uterus, &c.; and to stop a convulsive or spasmodic state of the respiratory apparatus. We should not, however, forget that the concussion occasioned by sneezing is not always free from dangerous results, especially in plethoric habits and persons disposed to apoplexy or affected with hernia, prolapsus of the uterus, &c."

ORDER 2. EXPECTORANTIA (from *ex*, out of, and *pectus*, the breast).—Medicines which promote the evacuation of mucus and other secreted matters from the bronchia, trachea, and larynx, are called *expectorants*.

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[1] *On the Diseases and Derangements of the Nervous System*, p. 99, 1841.
[2] *Traité de Matière Médicale*, t. ii. p. 298.

Medicines which alleviate cough are called *bechics (bechica ; βηχικά*, from *βήξ, a cough*), or *cough-medicines (tussicularia* vel *tussiculosa)*. The substances used as such are commonly demulcents (see *ante*, p. 167), cerebro-spinals (see *ante*, p. 199), and expectorants.

The term expectorant is usually applied to agents which increase or promote the secretion of bronchial mucus. It has also been applied to medicines which aid the evacuation (expectoration) of the already-secreted bronchial mucus (*i. e.* to medicines which excite cough); to medicines which alter the quality of the bronchial mucus, and, by rendering it thinner and less viscid, assist the patient in bringing it up; and, lastly, to medicines which check very profuse secretion, and thereby enable the patient more easily to expectorate that which is produced.

The substances usually supposed to promote the secretion of bronchial mucus may be divided into two kinds: those which produce their effect by direct application to the bronchial membrane, and those which are administered by the stomach, and require to be absorbed before they act as expectorants.

The following list of expectorants is, with few exceptions, that drawn up by the late Dr. Duncan.[1]

1. TOPICAL.

Applied in the form of liquid to the fauces:—

Emollients and Demulcents in general.

Applied in the form of gas or vapour to the mucous membrane of the lungs:—

Nicotiana Tabacum—*Folia.*
Datura Stramonium—*Herba.*
Myrrha.
Pix liquida.
Olea volatilia.

Aqua.
Alcohol.
Ætherea.
Acidum benzoicum.
" aceticum.

Acidum sulphurosum.
Ammonia.
Ammoniæ carbonas.
Chlorinium.
Iodinium.

2. GENERAL.

Taken into the stomach and acting through the circulation:—

VEGETABLE.

POLYGALACEÆ.
  Polygala Senega—*Radix.*
TEREBINTHACEÆ.
  Balsamodendron Myrrha—*Gummi-resina.*
LEGUMINOSÆ.
  Copaifera; plurimæ species—*Oleo-resina.*
  Myrospermum peruiferum—*Balsamum.*
UMBELLIFERÆ.
  Galbanum officinale—*Gummi-resina.*
  Ferula Assafœtida—*Gummi-resina.*
  Ferula —— (?)—*Gummi-resina* (*Sagapenum*)
  Dorema Ammoniacum—*Gummi-resina.*
CINCHONACEÆ.
  Cephaëlis Ipecacuanha—*Radix.*
STYRACEÆ.
  Styrax Benzoin—*Balsamum*
  " officinale—*Balsamum.*
LILIACEÆ.
  Squilla maritima—*Bulbus.*
  Allium sativum—*Bulbus.*

INORGANIC.

Antimonii potassio-tartras.

Of all the classes of the Materia Medica none are more uncertain in their operation than expectorants. Most of the agents employed as such act relatively; that is, they obviate the causes which interfere with healthy secretion. Many of them are substances which modify the vital activity of the aërian membrane by an alterative influence, and in this way relieve bronchial affections, expectoration being by no means an essential part of their operation.

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[1] *Supplement to the Edinburgh New Dispensatory.* Edinburgh, 1829.

The topical expectorants are of two kinds,—some are emollients and demulcents, others are local stimulants. To the former belong not merely the liquids applied to the fauces, but also warm aqueous vapour when inhaled, and in that way applied to the bronchial membrane.

The general expectorants are also of two kinds—some being stimulating, others nauseating and relaxing. Probably all the stimulating expectorants act topically, after absorption, on the bronchial membrane with which they are brought into contact by means of the blood. Some of them, as garlic and assafœtida, have been detected by their odour in the breath, (see *ante*, p. 102). Emetina (and, consequently, ipecacuanha) and emetic tartar have, according to Magendie[1] and Orfila,[2] a specific influence over the lungs, which organs, in animals killed by these substances, are said to present traces of inflammation and congestion.

Expectorants, unlike several other orders of evacuants, are exclusively employed in maladies of the secreting organ on which they operate. The emollient and nauseating (emetic tartar and ipecacuanha) expectorants are adapted for the more acute forms of bronchial irritation and inflammation; the stimulating expectorants for the more chronic forms. Senega is a most valuable remedy in the latter stages of acute inflammation of the lungs and bronchial membrane. The fetid gums, especially assafœtida, are more particularly adapted for the subacute and chronic forms of bronchitis accompanied with spasm of the muscular fibres of the bronchi, and which is so commonly observed in those whose bronchial tubes and cells are dilated.

Irritating gases and vapours (as chlorine, the vapour of acetic or of benzoic acid, &c.) when inhaled, produce coughing, as well as an augmentation of secretion. " We provoke coughing," says Schwilgue,[3] " to favour the expulsion of foreign bodies introduced from without into the aërian tube, and especially of liquids. We have recourse to it to favour the expectoration of mucus, of membraniform concretions, and of pus, which have accumulated in the aërian passages, whenever the local irritation is not sufficiently great."

Order 3. Emetica (ἐμετικά; from ἐμέω, *I vomit*); *vomitoria*; *anacathartica* (ἀνακαθαρτικά; from ἀνακαθαιρω, *I cleanse or purge upwards*; *i. e.* by vomiting [or by expectoration?]).—Medicinal agents which are used for the purpose of promoting vomiting are called *emetics* or *vomits*: when they merely excite nausea, they are termed *nauseants* (*nauseantia*).

The number of medicinal substances capable of exciting vomiting is very great; but only a few of them are in common use. Their operation is promoted by repletion of the stomach, especially with tepid liquids; and by titillation of the fauces, and especially the velum pendulum palati.[4]

The following is a list of officinal emetics:—

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[1] *Formulaire.*

[2] *Toxicologie Générale*, t. i. p. 482, 4me éd. 1843.

[3] *Traité de Matière Médicale*, tom. ii. p. 296.

[4] When we titillate, by means of a feather or pen, the throat, to excite vomiting, care must be taken not to carry the feather so far back as to irritate the posterior part of the pharynx; for, in that case, we excite an act of deglutition instead of that of vomiting. A feather, introduced into the throat to excite vomiting, has, by being pushed too far down, been actually swallowed, without causing vomiting. (See *Medical Observations and Inquiries*, vols. iii. and iv.; and also, Dr. Marshall Hall, *On the Diseases and Derangements of the Nervous System*, p. 81.)

1. VEGETABLE.

Cruciferæ.
  Sinapis nigra—*Seminum pulvis.*
Cinchonaceæ.
  Cephaëlis Ipecacuanha—*Radix.*
Compositæ.
  Anthemis nobilis—*Flores.*
Solanaceæ.
  Nicotiana Tabacum—*Folia.*
Aristolochiaceæ.
  Asarum Europæum—*Folia.*
Liliaceæ.
  Squilla maritima—*Bulbus.*

2. INORGANIC.

Antimonii potassio-tartras.
Zinci sulphas.
Cupri sulphas.

Usually within twenty or thirty minutes after taking an emetic, a general feeling of uneasiness and nausea comes on. The pulse becomes small, feeble, and irregular; the face and lips grow pale; a distressing sensation of relaxation, faintness, and coldness of the whole system is experienced; the saliva flows copiously from the mouth; the eyes lose their lustre; and the whole countenance appears dejected. These symptoms, which constitute the first stage of vomiting, continue for a variable period, and are followed by the ejection of the contents of the stomach.

As soon as actual vomiting commences, the general phenomena are altered: the pulse becomes frequent and full, the temperature of the body increases, and a sweat breaks out on the face and other parts. During the act of vomiting, in consequence of the pressure made on the abdominal aorta, and the interruption to the circulation through the lungs, from the impeded respiration, the blood returns with difficulty from the head, the face swells and becomes coloured, the conjunctiva is turgid and red, the jugular veins are gorged, and tears burst from the eyes. The violent straining is often attended with pain in the head and eyes, and with the involuntary expulsion of the urine and fæces. The matters vomited vary according to circumstances: they may consist of the alimentary substances, bile, &c. contained in the stomach and duodenum previous to the exhibition of the emetic; of the fluids collected by the action of the emetic; and, lastly, of the emetic itself. Sometimes striæ of blood are observed, which usually come from the pharynx. The number of vomitings, and the ease with which they are effected, are liable to considerable variation, arising from the state of the digestive organs, the temperament of the patient, the state of the cerebral functions, &c.

When the vomiting has entirely ceased, the patient feels languid, oppressed, and drowsy, and the pulse becomes weak and slow: the exhaustion is sometimes so great as to be attended with fatal consequences. A case of this kind is alluded to by Dr. Paris,[1] in which an emetic was imprudently given to a patient in the last stage of phthisis,[2] with the intention of dislodging the pus with which the lungs were embarrassed: syncope was produced, from which the patient never recovered. Among other occasional ill consequences of vomiting may be mentioned comatose affections, uterine or pulmonary hemorrhages, hernia, abortion, suffocation, prolapsus of the uterus, rupture of the abdominal muscles, &c. These effects are produced by the violent muscular exertions which attend the act of vomiting. They suggest cautions as to the use of emetics. Thus, in apoplexy, and some other cerebral affections, or when a tendency thereto exists; in pregnancy, especially when miscarriage is threatened; in prolapsus uteri, hernia, aneurism, &c. the danger to be apprehended from emetics is obvious. The concussion which they excite sometimes dislodges gall-stones.

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[1] *Pharmacologia*, 9th ed. p. 204, 1843.

[2] "Consumptive persons ought not to be purged by a vomit." (Hippocrates, *Aphorisms*, Sect. 4, Aph. viii.)

The intensity and duration of the different stages of vomiting have no necessary relation to each other. Thus the sulphates of zinc and copper excite speedy vomiting, with but little nausea; while tobacco and tartarized antimony, on the other hand, produce great nausea and depression of system. Hence, when the depressing effects of emetics are required, as in inflammatory and other diseases, we employ the last-mentioned emetic.

Vomiting is a reflex spinal act. "In vomiting excited through the fauces, it is the trifacial which is the nerve of transmission; in vomiting induced by an emetic, by a renal calculus, or a gall-stone, it is the pneumogastric;[1] and in the vomiting of early pregnancy or dysmenorrhœa, it is a spinal nerve which is the incident excitor nerve. All these nerves convey the excitement ultimately to the medulla oblongata. This combines the action of the nerves which regulate the aperture of the cardia, the closure of the larynx, and the acts of expiration."[2]

The author just quoted gives the following short summary of the mechanism of vomiting:—"During the act of vomiting,—1, the larynx is closed; 2, the cardia is opened; and 3, all the muscles of expiration are called into action; but 4, actual expiration being prevented by the closure of the larynx, the force of the effort is expended upon the stomach, the cardia being open, and vomiting is effected."

The irritation produced by the exhibition of emetics gives rise to an increased secretion from the mucous follicles of the stomach and duodenum; as is shewn by the thick, filamentous, and viscid matters frequently ejected. We infer, also, that the action of the exhalants must be increased, inasmuch as persons who have taken only a few spoonfuls of emetic liquids sometimes bring up a very considerable quantity of fluid. Darwin mentions a man who vomited six pints of liquid, although he had only swallowed one. Bile is frequently thrown up, either alone or mixed with other fluids; but we must not infer from this that it had existed in the stomach previous to the exhibition of the emetic; for bile is not ordinarily rejected in the first efforts, but only in the subsequent vomitings; and the quantity increases in proportion to the length of time the vomiting continues. Emetics promote the secretion of bile, and probably of the pancreatic juice also. We presume that they likewise augment absorption during the stage of nausea, previously to the act of vomiting, and when the force of the circulation is reduced.

Of the substances employed as emetics, some (as mustard) appear to act merely as local irritants to the stomach, for they cause vomiting only when they have been swallowed. Others (as emetic tartar), however, may be termed *specific emetics*, since they induce vomiting, not only when they are introduced into the stomach, but also when injected into the veins.

Does emetic tartar, when introduced into the stomach, occasion vomiting by its direct topical action on this viscus, or is absorption necessary to its emetic effect? It is probable that it may act in both ways. Large doses may occasion vomiting by the gastric irritation they excite; but absorption appears to be necessary to the specific emetic effects.

When emetic tartar has entered the circulation (either by absorption or injection into the blood-vessels), does it occasion vomiting by acting "upon the organs from which the nervous energy for the movements of vomiting are derived, or upon the organs of motion themselves?" Müller[1] thinks that this is still a matter of doubt.

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[1] According to Müller (*Physiology*, by Baly, vol. i. p. 509), it is certainly probable that both the pneumogastric and splanchnic nerves act simultaneously in transmitting the irritation when emetic agents act on the stomach and intestines.

[2] Dr. M. Hall, *On the Diseases and Derangements of the Nervous System*, p. 104, Lond. 1841.

Emetics are employed for several purposes, of which the following are the most important[2]:—

1. To evacuate the stomach. They are resorted to for the purpose of expelling poisons (see *ante*, p. 159), undigested foods (crudities), or other foul matters (saburræ).

When the object is merely to empty the stomach of its contents, those emetics should be selected which occasion the least nausea and distress. For women and children, ipecacuanha is the mildest and safest emetic. For cases of poisoning, the sulphates of zinc and copper are preferred to emetic tartar: they operate speedily and effectually, but with less nausea than the last-mentioned salt. Other means of exciting vomiting in cases of poisoning have already been pointed out (see *ante*, p. 159).

2. To expel foreign bodies lodged in the throat or œsophagus. In cases of choking from the impaction of meat in the throat, the foreign body has been dislodged by provoking vomiting by means of a solution of emetic tartar injected into the veins (see *ante*, p. 132).

3. To excite nausea, and thereby to depress the vascular and muscular systems. For the fulfilment of this object emetic tartar is usually employed in strong subjects; but in females and children ipecacuanha is frequently substituted. Nauseants are used to reduce vascular action in some active hemorrhages, in inflammatory fever, and in acute inflammation of the lungs, testicles, mammæ, air-tubes, cellular membrane, skin, and joints: but in inflammation of the alimentary canal they are unsafe. They are employed to depress the tone of the muscular system in dislocations of the larger joints, and thereby to assist reduction by overcoming the force of the opposing muscles. In various spasmodic affections, as spasmodic asthma, hooping cough, &c., the efficacy of nauseating emetics is referable to their depressing influence over the muscular fibre.

Emetics have been recommended to promote the passage of gall-stones, which they are said to do partly by relaxing the muscular fibres of the gall-ducts, partly by the concussion which they effect. But in acute cases they are usually unnecessary, as violent vomiting and great depression generally attend the passage of a biliary calculus.

4. To promote secretion and excretion. In hepatic derangements, especially those dependent on a torpid condition of the portal vessels, and in some cases of dyspepsia, emetics prove highly serviceable;—probably by promoting the secretion and excretion of bile, pancreatic juice, and gastric mucus. In inflammatory affections of the bronchial tubes, of the larynx, and throat, emetics are often found useful: and they are so, probably, in part at least, by their augmenting secretion from the affected parts, and thereby promoting the resolution of the disease. The operation of an emetic is frequently succeeded by a soft, lax, and damp state of skin,—a condition highly favourable to the subsidence of very slight febrile disorders.

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[1] *Physiology*, by Baly, vol. i. p. 510.

[2] For an account of the uses of emetics, consult Dr. Fothergill's Inaugural Dissertation, "*De Emeticorum Usu in variis Morbis tractandis*," Edinb. 1736. An English translation of this is published in his *Medical Works*, by J. C. Lettsom, M.D. Lond. 1784.

ORDER 4. CATHARTICA (*καθαρτικά; from καθαίρω, I purge or cleanse*); *purgativa* seu *purgantia* (from *purgo*, I purge or cleanse).—Medicines which produce alvine evacuations are called *cathartics* or *purgatives*.

The following is a list of officinal cathartics:—

1. VEGETABLE.

RANUNCULACEÆ.
Helleborus niger—*Radix*.
" fœtidus—*Radix*.
CRUCIFERÆ.
Sinapis alba—*Semina integra*.
VIOLACEÆ.
Viola odorata—*Flores*.
LINACEÆ.
Linum catharticum—*Herba*.
GUTTIFERÆ.
Hebradendron — (?)—*Gummi-resina Gambogiæ*.
VITACEÆ.
Vitis vinifera—*Baccæ*.
RHAMNACEÆ.
Rhamnus catharticus—*Baccæ*.
LEGUMINOSÆ.
Cassia Fistula—*Leguminis pulpa*.
Tamarindus indica—*Legumen*.
Cassia; plurimæ species—*Folia Sennæ*.
Andira inermis—*Cortex*.
Copaifera; plurimæ species—*Oleo-resina*.
ROSACEÆ.
Rosa centifolia—*Petala*.
" canina—*Fructus*.
Prunus domestica—*Fructus siccatus*.
CUCURBITACEÆ.
Cucumis Colocynthis—*Fructûs pulpa*.
Momordica Elaterium—*Elaterium*.

COMPOSITÆ.
Taraxacum Dens-Leonis—*Radix*.
OLEACEÆ.
Olea europæa—*Fructûs oleum*.
Ornus europæa—*Succus concretus* (*Manna*).
CONVOLVULACEÆ.
Convolvulus Scammonia—*Resina*.
Ipomæa Purga—*Radix*.
SOLANACEÆ.
Nicotiana Tabacum—*Folia*.
POLYGONACEÆ.
Rheum; plurimæ species—*Radix*.
EUPHORBIACEÆ.
Croton Tiglium—*Oleum*.
Ricinus communis—*Oleum*.
Euphorbia — (?)—*Resina* (*Euphorbium*).
URTICACEÆ.
Ficus Carica—*Fructus*.
CONIFERÆ.
Pinus; plurimæ species—*Oleum Terebinthinæ*.
Juniperus Sabina—*Folia*.
LILIACEÆ.
Aloë; plurimæ species—*Succus concretus*.
MELANTHACEÆ.
Colchicum autumnale—*Cormus*.
Veratrum album—*Cormus*.
GRAMINEÆ.
Hordeum distichon—*Semina*.
Saccharum officinarum—*Saccharum impurum*.

2. ANIMAL.

Mel.

3. INORGANIC.

Sulphur.
Magnesia.
Magnesiæ carbonas.
" sulphas.
Potassæ sulphas.

Potassæ tartras.
" bitartras.
Sodii chloridum.
Sodæ sulphas.
" phosphas.

Sodæ potassio-tartras.
Hydrargyri chloridum.
Pilula hydrargyri.
Antimonii potassio-tartras.
Pulvis antimonii compositus.

Cathartics cause alvine evacuations by increasing the peristaltic motion of the intestines and by promoting secretions from the mucous lining. The milder purgatives, however, operate principally by their influence on the muscular coat of the intestines; while the stronger ones stimulate the mucous follicles and exhalants, and give rise to liquid evacuations. The former are sometimes termed *eccoprotics* (*eccoprotica; from ἐκκόπρωσις, a cleansing from dung, a purging*); while the latter are denominated *hydragogues* (*hydragoga; ὑδραγωγά*, from *ὕδωρ, water*, and *ἀγωγός, eliciting* or *evoking*). Some of them create nausea, faintness, occasionally vomiting, colicky pains, abdominal tenderness, and tenesmus. The more violent ones, if given in an over-dose, produce inflammation of the alimentary canal,[1] characterised by violent vomiting and purging, abdominal pain and tenderness, cold extremities, and sinking pulse. These are denominated *drastics* (*drastica* ; *δραστικά*, from *δράω*, *I am active*). Emollient or demulcent drinks (as barley water, gruel, and broth) are taken to favour their safe operation.

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[1] The deaths from the use of Morison's Pills are referable to this. The active ingredient of these medicines is gamboge (see *Lond. Med. Gaz.* vol. xiv. pp. 612 and 759; vol. xvii. pp. 357, 415, and 623; vol. xviii. pp. 75 and 927; vol. xix. p. 976).

As the intestinal surface consists of about 1400 square inches,[1] from the whole of which secretion and exhalation are going on, it is obvious that purging offers a very powerful means of diminishing the quantity of the fluids of the body; and accordingly we find that some cathartics, especially elaterium, cause very copious watery discharges; and their employment is followed, as might be expected, with thirst and augmented absorption from the serous cavities, so that they sometimes reduce or even remove dropsical swellings. The more violent purgatives promote the discharge of bile and pancreatic liquor, by the irritation they produce at the termination of the ducts which pour these secretions into the alimentary canal.

A distinction is usually made in practice between *cooling* and *warm* purgatives. By the former are commonly meant saline purgatives which, while they cause purging, without having any tendency to excite inflammation, are supposed to have a refrigerant influence over the system, and are adapted for febrile and inflammatory cases. By the latter are meant the more violent cathartics, which are presumed either to quicken the pulse, or at least to excite the abdominal vascular system, and, therefore, are considered to be less fitted for febrile cases.[2]

The more powerful cathartics are acrids or local irritants. Some of them (*e. g.* gamboge) operate almost solely in this way; for they do not excite purging except when they are introduced into the alimentary canal, and they easily excite vomiting when swallowed. But most of the drastics exert, in addition, a specific influence over the alimentary canal, so that they excite purging when injected into the veins, or when applied either to the serous membranes or cellular tissue. Senna, castor and croton oils, black hellebore, colocynth, and elaterium, operate in this way. This circumstance, therefore, favours the notion that they act, in part at least, after absorption.

A considerable number of cathartic substances have been detected in the blood and secretions (see *ante*, pp. 101 and 102).

The physical (endosmotic) action of purgative solutions has been already alluded to (see *ante*, pp. 91 and 92).

Some cathartics act also as diuretics, as bitartrate of potash and gamboge. Dr. Christison[3] observed, that where diuretics have been given for some time without effect, he has frequently seen their action brought on "by a single dose of some hydragogue cathartic, such as gamboge." The resinous particles, in their passage out of the system through the renal vessels, probably acted as topical stimulants.

Cathartics probably act, in part at least, by a reflex action of the ganglionic system. Müller[4] observes, that galvanising the splanchnic nerve or the cœliac ganglion, gives rise to a generally increased activity of the peristaltic movements, while division neither of the pneumo-gastric nor of the sympathetic nerve puts a stop to them. This appears to show that the splanchnic nerve is concerned in propagating the irritation set up by cathartics. The tenesmus occasioned by some cathartics is a reflex action of the true spinal system.

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[1] This measurement has been calculated from the statements as to the length and diameter of the intestines in Meckel's *Manuel d'Anatomie générale, descriptive et pathologique.* Traduit par J. A. L. Jourdan et G. Breschet. Paris, 1825.

[2] An anonymous writer, in the *London Medical Gazette*, vol. iv. p. 139, contends that aloes is not a warm purgative, though usually considered to be so.

[3] *On Granular Degeneration of the Kidneys*, p. 150, Edinburgh, 1839.

[4] *Physiology*, by Baly, vol. i. p. 511.

Different parts of the alimentary canal are unequally affected by different cathartics. Thus aloes is remarkable for its action on the large intestine; moreover, many of the drastic cathartics—as gamboge, colocynth, savin, and black hellebore—create more irritation in the large than in the small intestines; and Orfila[1] mentions that, in animals killed by these substances, he found the stomach and rectum inflamed, while the small intestines were healthy. In some cases, perhaps, this may be ascribed to the rapidity with which these agents pass through the small intestines, and on their longer continuance in the stomach and rectum; but the same appearance has been noticed when these cathartics have been applied to the cellular texture of the thigh.

Cathartics may be conveniently arranged in five groups, as follows:—

1. *Laxatives* or *lenitives* (*laxativa* vel *laxantia; lenitiva*).—This group contains the *mild cathartics* (*purgantia mitiora*), such as manna, cassia pulp, tamarinds, prunes, honey, bitartrate of potash, and the fixed oils (as castor, almond, and olive oils). These very gently evacuate the contents of the intestinal canal, and usually without causing any obvious irritation, or affecting the general system. Manna, however, is apt to occasion flatulence and griping. Laxatives are employed in any cases where we wish to evacuate the bowels with the least possible irritation,—as in children and pregnant women; in persons afflicted with inflammation of any of the abdominal or pelvic viscera, with hernia, prolapsus of the womb or rectum, piles, or stricture of the rectum; and after surgical operations about the abdomen and pelvis.

2. *Saline, antiphlogistic,* or *cooling cathartics* (*purgantia salina, antiphlogistica*).—This order is composed of the *saline* purgatives, such as the sulphates of soda, potash, and magnesia, &c. They increase the peristaltic motion of the alimentary canal, and augment the effusion of fluids by the exhalants of the mucous surface, thereby giving rise to watery stools.

If administered in the form of very dilute aqueous solutions they no longer act as cathartics, but become absorbed and act as diuretics (see *ante*, pp. 92 and 180). To operate as purgatives the solutions should be richer in saline matter than the blood is.[2]

3. *Milder acrid cathartics* (*purgantia intermedia*).—This order includes senna, rhubarb, and aloes. These are more active substances than any of the preceding. They are acrids and stimulants, but their local action is not sufficiently violent to cause inflammation. Senna is employed where we want an active, though not very acrid or irritant, purgative. Rhubarb is administered in relaxed and debilitated conditions of the alimentary canal, on account of its tonic properties. Aloes is used in torpid conditions of the large intestines, and in affections of the head. It is usually considered objectionable in piles and diseases of the rectum.

4. *Drastic cathartics* (*drastica; purgantia fortiora*). This group comprehends the *strong acrid purgatives;* such as jalap, scammony, black

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[1] *Toxicologie générale.*

[2] According to Liebig (*Researches on the Motion of the Juices in the Animal Body*, p. 60, Lond. 1848,) the blood contains from ¾ to 1 per cent. of common salt; consequently, saline solutions, to act as purgative, should contain more than one per cent. of saline matter. As this physical action of salts is common to all, and is independent of the nature of the acids and bases composing them, it is obvious that it does not explain why one salt is more purgative than another.

hellebore, gamboge, croton oil, colocynth, and elaterium. These, when swallowed in large doses, act as acrid poisons. They are employed as purgatives in torpid conditions of the bowels; as hydragogues in dropsical affections; and as counter-irritants in affections of the brain. They are objectionable remedies in inflammatory and irritable conditions of the alimentary canal.

5. *Mercurial cathartics* (*purgantia mercurialia*).—The principal of these are the hydrargyrum cum cretâ, the pilula hydrargyri, and calomel. We employ them as alterative purgatives, and to promote the hepatic functions. As they are uncertain in their operation they are usually combined with, or followed by, other purgatives.

The following are the principal general uses[1] of cathartics :—

1. To evacuate the contents of the alimentary canal, and thereby to relieve those morbid symptoms which arise from their presence. The substances, which cathartics are employed to remove, are retained feculent matters, undigested foods, morbid secretions, worms (see *ante*, p. 228), and poisonous agents (see *ante*, p. 160).

2. To promote secretion and exhalation from the gastro-intestinal mucous surface. Cathartics are employed directly for the production of this effect, and indirectly for the attainment of other objects, of which the following are the chief :—

α. The establishment of healthy alvine secretion when this is defective or perverted, especially in torpid conditions of the alimentary canal.

β. The promotion of the elimination of morbid agents contained in the blood,—either absorbed poisons (see *ante*, p. 160), or retained principles which ought to have been evacuated by other excreting organs.

γ. The diminution of the volume of the circulating fluid and the relief of plethora, congestion, and other maladies dependent thereon.

δ. The augmentation of the action of the absorbents. Hydragogues which carry a large quantity of fluid out of the system by the bowels promote absorption, and thereby oftentimes prove most beneficial in dropsies.

ε. The antagonism of other secretions. Thus cathartics are employed to check excessive ptyalism from mercury, and to diminish the secretion of milk in nurses who are weaning.

ζ. The establishment of a substitute for other secretions. Thus, in defective secretion from the uterus, kidneys, &c., cathartics are employed to relieve the morbid symptoms resulting therefrom.

η. The relief of inflammation. Cathartics are frequently employed as antiphlogistics. They assist in removing or counteracting some of the elements of inflammation; and they do this in part by promoting secretion and exhalation from the gastro-intestinal canal; by which they relieve congestion of, and determination to, inflamed parts, lessen inflammatory fever, and promote the expulsion of morbid agents from the system and the absorption of some of the effused products of inflammation.

3. To promote the secretion of the liver and pancreas. By irritating the orifice of the ductus communis choledicus, active cathartics produce an augmented secretion and excretion of bile and pancreatic juice; and hence these agents are well fitted for relieving those symptoms which arise from congestion or torpor of the portal system.

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[1] On this subject, consult *Observations on the Utility and Administration of Purgative Medicines several Diseases*, by J. Hamilton, M.D. Edinb. 1806. 3d edit. 1809.

4. To stimulate or excite the muscular fibres of the alimentary canal, and thereby to relieve torpor, inactivity, or even a paralysed state of this organ. The torpor referred to exists chiefly in the cæcum and colon, and is most frequently met with in females. Although it is greatly relieved by the use of cathartics, these in general give only temporary relief: indeed, it not unfrequently happens that, after their action is over, the inactivity of bowel is augmented. Tonics, especially iron, and, in some cases, minute doses of the extract of nux vomica, aided by the occasional employment of cathartics, sometimes prove most effective. Aloetic purges are particularly useful when the condition of the uterus and rectum do not prohibit their use.

5. To effect remote organs on the principle of revulsion or counter-irritation (see *ante*, p. 123). Cathartics operate as revulsives or counter-irritants by the powerful impression which they make on the intestinal nerves, by the determination of blood they produce to the abdominal organs, and by the augmentation of secretion (intestinal, hepatic, and pancreatic) which they effect. They often prove most effective remedial agents in affections of the brain and other remote organs. In chorea, hysteria, determination of blood to the brain, or threatened apoplexy, and various other maladies, cathartics are most valuable remedies, operating apparently on the principle of counter-irritation.

6. To promote the catamenia. Some of the more active purgatives, particularly those which act in an especial manner on the large intestine, extend their irritating or stimulating influence to the whole of the pelvic vessels, and in this way frequently prove emmenagogue.

ORDER 5. DIAPHORETICA (διαφορητικά; from διαφορέω, *I throw off by perspiration*); *sudorifica* vel *sudorifera* (from *sudor*, sweat, and *facio*, I make, or *fero*, I produce); *hidrotica* (ἱδρωτικα; from ἱδρωω, *I perspire*); *diapnoica* (διαπνοϊκά (?); from διαπνοή, *evaporation* or *exhalation*.—Medicinal agents which promote the cutaneous transpiration are called *diaphoretics* or *sudorifics*.

The terms *diaphoretics* and *diapnoïcs* have been used to designate substances which augment the insensible perspiration; while the words *sudorifics* and *hydrotics* indicate substances increasing the sweat or sensible perspiration. But insensible perspiration and sweat differ in their physical conditions only; the former being the vaporous, the latter the liquid state of the same fluid. Hence there can be no essential difference between diaphoretics and sudorifics, and I, therefore, use the terms synonymously.

The agents which, under certain circumstances, augment cutaneous exhalation, are both numerous and heterogeneous. External heat, assisted by the copious use of diluents, constitutes an important and powerful means of promoting sweating. Whenever a large quantity of fluid is taken into the system, the excess is got rid of by the kidneys, the skin, and the lungs; and if we keep the skin warm, as by warm clothing, or the use of hot air or hot vapour-bath (see *ante*, pp. 13, 15, and 17), the action of the cutaneous exhalants is promoted, and sweating results; but if the skin be kept cool, the kidneys are stimulated, and the greater part of the liquid passes off through them. Friction, exercise, and all agents which excite vascular action, have a tendency to promote sweating. The sudden and temporary application of cold, as in the affusion of cold water (see *ante*, p. 30), sometimes proves sudorific by the reaction which it occasions. Lastly, many medicinal agents, acting through the circulation, cause sweating. These are the sudorifics or diaphoretics properly so called.

The following is a list of the officinal diaphoretics :—

1. ORGANIC.

PAPAVERACEÆ.
  Papaver somniferum—*Opium.*
CRUCIFERÆ.
  Sinapis nigra—*Semina.*
POLYGALACEÆ.
  Polygala Senega—*Radix.*
TERNSTROMIACEÆ.
  Thea viridis—*Folia.*
  " Bohea—*Folia.*
ZYGOPHYLLACEÆ.
  Guaiacum officinale—*Resina.*
LEGUMINOSÆ.
  Copaifera; plurimæ species—*Oleo-resina.*
CINCHONACEÆ.
  Cephaëlis Ipecacuanha—*Radix.*
ASCLEPIADACEÆ.
  Hemidesmus indicus—*Radix.*
SOLANACEÆ.
  Solanum Dulcamara—*Stipites.*
  Capsicum annuum—*Fructus.*
LABIATÆ.
  Hyssopus officinalis—*Herba.*
  Melissa officinalis—*Herba.*
  Mentha Pulegium—*Herba.*
  Rosmarinus officinalis—*Herba.*
  Salvia officinalis—*Herba.*
THYMELACEÆ.
  Daphne Mezereum—*Cortex radicis.*
LAURACEÆ.
  Camphora Officinarum—*Camphora.*
  Sassafras officinale—*Lignum.*
  Laurus nobilis—*Folia.*
ARISTOLOCHIACEÆ.
  Aristolochia Serpentaria—*Radix.*
URTICACEÆ.
  Dorstenia Contrajerva—*Radix.*
ULMACEÆ.
  Ulmus campestris—*Cortex.*
SMILACEÆ.
  Smilax; plurimæ species—*Radix Sarsæ.*

Alcohol.
Vinum.

Ætherea.

Olea volatilia.
" empyreumatica.

2. INORGANIC.

Ammoniæ sales.
Salia neutra (see *ante*, p. 178).

Antimonialia } (see *ante*, p. 184).
Mercurialia }

Diaphoretics are relative agents; they succeed only in certain states of the body. Moreover, for different conditions different diaphoretics are required. They constitute an exceedingly uncertain class of remedies, with regard both to the production of sweating and to the advantage to be derived therefrom. Dr. Holland[1] suggests that when benefit follows the use of diaphoretic medicines, it is often ascribable, not to their direct influence on the exhalant vessels, but to other changes which they excite in the system, of which sweating is to be regarded rather as the effect and proof than as the active cause.

The operation of diaphoretics is promoted by the exhibition of large quantities of warm mild diluents, and by keeping the skin warm. Moreover, they are more effective when given at bed-time, since there appears to be greater disposition to sweating during sleep than in the waking state. The exhibition of diuretics should be avoided during the operation of diaphoretics, as they appear to check the operation of the latter. The same rule has been laid down with regard to purgatives; but it is well known that perspiration is often the consequence of hypercatharsis.

Dr. Edwards[2] has shewn that cutaneous transpiration is effected in two ways,—by a physical action or evaporation, and by an organic action or transudation. *Evaporation*, or the physical action, is the consequence of the porosity of bodies, and takes place equally in the dead and living state.

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[1] *Medical Notes and Reflections*, p. 52, Lond. 1839.

[2] *De l'Influence des Agens Physiqûes sur la Vie*, Paris, 1824.

It is influenced by the hygrometric states of the surrounding air, by its motion or stillness, by its pressure, and by its temperature. Thus dryness, agitation, and diminution of the weight of the air, increase it. *Transudation*, or the organic action of transpiration, is a vital process, effected by minute spiral follicles or sudoriferous canals, and depends essentially on causes inherent in the animal economy, although it may be influenced to a certain extent by external agents. Thus, elevating the temperature of the surrounding air, preventing its frequent renewal, and covering the patient with warm clothing, are means which promote the organic, but check the physical, action of transpiration. Diaphoretics affect the transudation or the vital process. They probably affect the exhalants in one or both of two ways;—by increasing the force of the general circulation, or by specifically stimulating the cutaneous vessels.

Diaphoretics may be arranged in seven groups, as follows:—

1. *Aqueous diaphoretics.*—Under this head are included not only simple water, but gruel, whey, and tea. These, when assisted by external warmth, often prove very effective diaphoretics, even when used alone; while to all the other groups they are valuable adjuvants; and in no cases are they injurious.

2. *Alkaline and saline diaphoretics.*—The salts of the alkalies are frequently used to promote perspiration. Acetate and carbonate of ammonia, alkaline citrates and tartrates, sal ammoniac, and nitrate of potash, are employed for this purpose in fevers.

3. *Antimonial diaphoretics.*—The liquefacient operation of antimonials has been already referred to (see *ante*, pp. 175 and 184). Diaphoresis is one of its consequences. We use this group of diaphoretics in febrile and inflammatory cases. It is preferred to the opiate diaphoretics when there is inflammation or congestion of the brain, or a tendency to either of these conditions.

4. *Opiate diaphoretics.*—Opium and its alkali morphia have a remarkable tendency to produce sweating. The former is often used as a diaphoretic, commonly in the form of Dover's powder, when no disorder of the brain exists; and especially when an anodyne is indicated. When the stomach is very irritable, an opiate diaphoretic is preferred to an antimonial one. In rheumatism and slight catarrhs, Dover's powder proves highly serviceable. In diabetes and granular disease of the kidneys, it is the best sudorific we can use, especially when conjoined with the warm bath.[1] Opium and camphor form a serviceable sudorific compound when the surface is cold, as in cholera.

5. *Oleaginous and resinous diaphoretics.*—This group includes a large number of substances, some of which owe their activity to volatile oil, as the Labiatæ and the Lauraceæ (*e. g.* sassafras and camphor); others to resin, as mezereon and guaiacum; while some contain both oil and resin, as copaiva and the turpentines. The substances of this order possess stimulant properties. They probably act locally on the cutaneous vessels through the blood; for some of them (*e. g.* copaiva) can be detected by their odour in the perspiration, and they occasionally excite a slight eruption on the skin. The diaphoretics of this group are useful in chronic rheumatism, secondary syphilis, and chronic cutaneous diseases.

6. *Alcoholic diaphoretics.*—Alcohol and wine augment cutaneous exhalation.

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[1] See Dr. Osborne's paper, in *The Dublin Journal of Medical and Chemical Science*, Jan. 1834. Also Dr. Christison, *On Granular Degeneration of the Kidneys*, Edinb. 1839.

7. *Ipecacuanha.*—I believe the diaphoretic property of ipecacuanha to be considerably less than is commonly supposed. Dover's powder owes its power of producing sweating almost exclusively to the opium which it contains.

Diaphoretics are employed for various purposes, of which the following are the chief:—

1. To restore the cutaneous secretion when it has been checked by cold, and thereby to relieve the ill consequences of its suppression. The milder forms of disease, induced by what is familiarly termed "catching cold," are oftentimes successfully treated by the use of diluents and diaphoretics. In catarrhal and rheumatic affections they are employed with great benefit.

2. To promote the subsidence of diseases which naturally terminate by augmented cutaneous secretion or exanthematous eruptions; as in simple continued fever, the exanthemata, and intermittents.

3. To produce determination to the surface in various maladies attended with coldness of the skin and congestion of internal organs.

4. To antagonise other secretions. Thus diaphoretics are employed to check excessive secretion of urine (see *ante*, p. 126), and sometimes to relieve diarrhœa. Opium is a valuable agent in some of these cases; for, while it acts as a diaphoretic, it checks secretion from the kidneys and intestines: and hence in diabetes and diarrhœa it serves a two-fold purpose.

5. To establish a substitute for some other secretion. Both the skin and kidneys are engaged in the common function of eliminating water; and hence when the renal secretion is diminished or suppressed we endeavour to relieve the system by the use of diaphoretics. In dropsy from granular degeneration of the kidney, the employment of warm-baths and Dover's powder is frequently attended with great benefit.

ORDER 6. SIALAGOGA (σιαλαγωγά (?); from σίαλον, *saliva*, and ἀγωγός, *eliciting* or *evoking*); *ptyalagoga* (πτυαλαγωγά (?); from πτύαλον, *saliva*, and ἀγωγός).—Medicines which augment the secretion of saliva and buccal mucus are denominated *sialagogues*.

Sialogogues are of two kinds: some produce their effect by direct application to the mouth; others are swallowed, and require to be absorbed before they act as such. The former are called *topical sialagogues*; the latter are the *remote* or *specific sialagogues*.

SUB-ORDER α. TOPICAL SIALAGOGUES.—These are sialogogues which are applied to the mouth. When used in a soft or solid state they are called *masticatories* (*masticatoria*; from *mastico*, I eat or chew). They act on the mucous follicles of the mouth and the salivary glands. Most solid or soft bodies, when chewed, increase the flow of saliva; but acrids do this in an eminent degree. The following is a list of officinal topical sialagogues:—

CRUCIFERÆ.
  Cochlearia Armoracia—*Radix*.
SOLANACEÆ.
  Nicotiana Tabacum—*Folia*.
COMPOSITÆ.
  Anacyclus Pyrethrum—*Radix*.

THYMELACEÆ.
  Daphne Mezereum—*Cortex radicis*.
ZINGIBERACEÆ.
  Zingiber officinale—*Rhizoma*.

In almost all parts of the world masticatories are more or less used. In the East Indies betel-nuts (the seeds of Areca Catechu) are chewed, with quicklime and the betel leaf (the leaf Piper Betel). The Indians have a notion that these substances fasten the teeth, clean the gums, and cool the mouth.[1] In this country the masticatory commonly employed by sailors is tobacco.

As the saliva is generally swallowed, masticatories do not confine their action to the mouth, but excite likewise the stomach. Peron[2] was convinced that he preserved his health, during a long and difficult voyage, by the habitual use of the betel; while his companions, who did not use it, died mostly of dysentery. For habitual use, and as mere sialagogues, mucilaginous and emollient masticatories might be resorted to, but we find that acrids of various kinds have always been preferred. Masticatories, as therapeutic agents, have been principally used either as topical applications in affections of the gums, tongue, tonsils, salivary glands, &c., or as counter-irritants in complaints of neighbouring organs, as in ear-ache, rheumatism of the pericranium, affections of the nose, &c. The stronger masticatories, as mustard and horse-radish, excite an increased discharge of nasal mucus and tears, as well as of saliva and mucus of the mouth.

SUB-ORDER β. SPECIFIC OR REMOTE SIALAGOGUES.—Several substances have had the reputation of producing salivation or ptyalism by internal use. Of these, the preparations of mercury (see *ante*, p. 184) are the only ones on which much reliance can be placed, and even they sometimes disappoint us. The preparations of gold, of antimony (see *ante*, p. 184), and of iodine (see *ante*, p. 182), occasionally have this effect. The continued use of the hydrocyanic or nitric acid has, in several instances, produced salivation. In poisoning by foxglove the same has been observed. Lastly, nauseants increase the secretion of saliva. Mercurials are given in certain diseases to excite ptyalism, and in some cases it is necessary to keep up this effect for several weeks. It is not, however, supposed that the salivation is the cause of the benefit derived, but an indication that the constitution is sufficiently influenced by the medicine.

ORDER 7. CHOLAGOGA (χολαγωγά; from χολή, *bile*, and ἀγωγός, *eliciting* or *evoking*).—Medicines which promote the secretion or excretion of bile are denominated *cholagogues*.

It is probable that most, if not all, drastic purgatives increase the secretion and excretion both of bile and pancreatic juice, by irritating [illegible] opening of the ductus choledochus in the duodenum; just as certain substances, taken into the mouth, provoke an increased discharge of saliva, by irritating the mouths of the salivary ducts. Graaf[3] says, that if a purgative be administered to a dog, and, when it is beginning to operate, the abdomen be laid open, the bile and pancreatic juice will be observed flowing into the duodenum.

The agents before noticed under the name of liquefacients (see *ante*, p. 175) probably increase the secretion of bile in common with the other secretions.

The term cholagogue, however, has been more particularly applied to substances which have been supposed to have a specific influence in promoting the secretion or excretion of bile. Mercury, aloes, rhubarb, and taraxacum, have been considered to possess this property.

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[1] Ainslie's *Materia Indica*.

[2] *Voyage aux Terres Australes*, Paris.

[3] Barbier, *Traité Elément. de Mat. Méd.* t. iii. p. 1252, 2nde éd.

Cholagogues are employed to promote the secretion and excretion of bile in maladies in which these functions are defective, and generally in torpid conditions of the portal system.

ORDER 8. DIURETICA (διουρητικά; from διά, *throughly*, and οὐρητικά); *uretica* (οὐρητικά; from οὐρέω, *I make water*); *urinalia*.—Medicinal agents which promote the secretion of urine are called *diuretics*.

The following is a list of the officinal diuretics:—

1. VEGETABLE.

MENISPERMACEÆ.
  Cissampelos Pareira—*Radix*.
CRUCIFERÆ.
  Cochlearia Armoracia—*Radix*.
  " officinalis—*Herba*.
  Sinapis nigra—*Semina*.
  " alba—*Semina*.
POLYGALACEÆ.
  Polygala Senega—*Radix*.
GUTTIFERÆ.
  Hebradendron — (?)—*Gummi-resina Gambogiæ*.
RUTACEÆ.
  Barosma; plurimæ species—*Folia* (*Buchu*).
LEGUMINOSÆ.
  Copaifera; plurimæ species—*Oleo-resina*.
  Cytisus scoparius—*Summitates*.
MYRTACEÆ.
  Melaleuca minor—*Oleum Cajuputi*.
UMBELLIFERÆ.
  Petroselinum sativum—*Radix*.
  Daucus Carota—*Fructus*.

COMPOSITÆ.
  Taraxacum Dens-Leonis—*Radix*.
PYROLACEÆ.
  Chimaphila umbellata—*Folia*.
ERICACEÆ.
  Arctostaphylos Uva-ursi—*Folia*.
SOLANACEÆ.
  Nicotiana Tabacum—*Folia*.
SCROPHULARIACEÆ.
  Digitalis purpurea—*Folia*.
PIPERACEÆ.
  Piper Cubeba—*Fructus*.
CONIFERÆ.
  Pinus; plurimæ species—*Oleum terebinthinæ*.
  Juniperus communis—*Oleum volatile*.
MELANTHACEÆ.
  Colchicum autumnale—*Cormus*.
LILIACEÆ.
  Squilla maritima—*Bulbus*.
  Asparagus officinalis—*Radix*.

Alcohol.
Vinum (Rhenanum).
Spiritus ætheris nitrici.

2. ANIMAL.

Cantharis vesicatoria.

3. INORGANIC.

Alkalina (see *ante*, p. 176).
Salia neutra et media (see *ante*, p. 178).
Sapo.
Iodica et bromica (see *ante*, p. 182).
Acida mineralia diluta (see *ante*, p. 170).
Mercurialia et antimonialia (see *ante*, p. 184).
Aqua.

There are two principal modes of promoting the secretion of urine: the one direct, the other indirect. The *indirect* method consists in augmenting the quantity of fluids taken into the stomach, or in removing any cause which checks the secretion. The *direct* mode is to stimulate the kidneys by means which specifically affect these organs. These means are the diuretics properly so called.

The quantity of urine secreted in the healthy state is liable to considerable variation. Temperature, season of the year, climate, time of day, quantity of fluid consumed as drink, state of health, &c., are among the common circumstances modifying this secretion. Whenever an unusual quantity of aqueous fluid is taken into the system, the kidneys are the organs by means of which the excess is, for the most part, got rid of. If the customary discharge from the skin or lungs be checked, by cold, for instance, the kidneys endeavour to make up for the deficiency of action in the other organs. Thus in winter and in cold climates, more urine is secreted than in summer and in hot climates. Again, if transpiration be promoted, as by external warmth, the secretion of urine is diminished. Hence, when we wish to augment the renal secretion, diluents should be freely administered, and the skin kept cool.

Mr. William Alexander[1] endeavoured to determine, as nearly as possible, the relative powers of different diuretics; and he has given the following tabular views of his results:—

A TABLE *of the different quantities of urine always discharged in an equal time; viz. from nine o'clock in the morning till two o'clock in the afternoon, when an equal quantity of the same liquid was drunk, but with different diuretics, in different quantities, dissolved in it.*

	℥	ʒ	℈
By ℔j. ʒvijss. of simple infusion of bohea tea, standard	15	4	0
Ditto, with ʒij. of salt of tartar	22	7	2
" ʒij. of nitre	22	0	0
" 4 drops of oil of juniper	30	3	0
" ʒj. of salt of wormwood	19	7	1½
" ʒij. of Castile soap	19	1	1
" a teaspoonful of spt. nitr. dulc.	17	6	1½
" 15 drops of tinc. cantharides	16	4	0
" ʒij. of sal. polychrest	16	3	0
" ʒss. of uva ursi	16	1	0½
" ʒj. of magnesia alba	15	5	0
" ʒij. of cream of tartar	10	2	0½

A TABLE *of the different quantities of urine evacuated in the same space of time, after drinking the same quantity of different liquors.*

	℥	ʒ	℈
By ℔j. ℥vijss of weak punch, with acid	21	2	3
" new cow whey	18	6	0
" decoct. diuret. Pharm. Edin.	17	5	0
" London porter	16	7	0
" decoct. bardan. Pharm. Edin.	14	7	0
" warm water gruel	14	6	2
" small beer	13	7	1
" warm new milk	11	7	0

These tables are to a certain extent useful; but as diuretics act very unequally at different times, and cannot, therefore, be relied on, the value of Mr. Alexander's experiments is considerably diminished.

By augmenting the secretion of urine we diminish the quantity of blood in the blood-vessels; and thus create thirst and promote absorption from the serous cavities.

There is reason to believe that all diuretic medicines, strictly so termed, become absorbed, are carried in the blood to the kidneys, and are there eliminated, either unchanged or more or less altered. I have already (see *ante*, pp. 101—102) enumerated the medicinal agents which have been detected in the urine. To the list before given may be added the following, which, according to Dr. Vetter,[2] pass off by urine:—

Asparagin.
Almost all astringents.
Acrid matter of cubebs.
Balsam of copaiva.
Veratria.

We must not, however, imagine that every substance which can be detected in the urine is a diuretic, for in some instances this is evidently not the case; and, on the other hand, there are several medicines whose active principles are supposed to excite an increased flow of urine by absorption and local contact with the renal vessels, but which cannot be recognised in this secretion on account of the absence of any known sensible or chemical characters by which these principles can be readily detected.

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[1] *Experimental Essays*, Edinb. 1768.

[2] *Pharmaceutisches Central Blatt für* 1837, p. 811.

It is probable that all agents which prove diuretic by their direct stimulant influence over the kidneys do so by their topical action on these organs (see p. 110). It follows, therefore, that in order to enable them to reach the kidneys they must be administered either in solution or in such a condition that they may become dissolved in the fluids of the gastro-intestinal canal. Moreover, the solutions should be very dilute; otherwise, instead of becoming absorbed, they act as cathartics (see *ante*, p. 92). I have before referred to Laveran and Millon's experiments with tartarized soda (see *ante*, p. 180). When solutions of this salt caused purgation, they did not become absorbed: on the contrary, solutions which did not purge became absorbed and rendered the urine alkaline.

Mr. Bowman[1] considers that "the parts concerned in the secretion of that portion of the urine to which its characteristic properties are due (the urea, lithic acid, &c.)" are the uriniferous tubes and their plexus of capillaries; and that the Malpighian bodies are "an apparatus destined to separate from the blood the watery portion." Diuretic medicines, he says, "appear to act specially on the Malpighian bodies; and various foreign substances, particularly salts, which, when introduced into the blood, pass off by the urine with great freedom, exude, in all probability, through this bare system of capillaries. The structure of the Malpighian tubes indicates this; and also, as far as they are known, the laws regulating the transmission of fluids through organized tissues, modified in their affinities by vitality."

The uncertainty of the action of diuretic medicines in the cases in which their influence is especially desired—namely, in dropsies, is well known to every practitioner. Now, in a very large majority of cases, dropsy arises from organic disease of the heart, kidneys, liver, or lungs; and to the influence of these maladies must be referred the failure of the so-called diuretics to augment the secretion of urine. "If," says Dr. Barlow,[2] "a sufficient quantity of water cannot be received into the small intestines, or the circuit through the portal system in the vena cava ascendens, or thence through the lungs and heart into the systemic circulation, be obstructed; or if there be extensive disorganization of the kidneys, the due secretion of urine cannot be effected."

When the obstruction exists in the portal system, medicines calculated to relieve this should be conjoined with the diuretics, whose operation they greatly promote. Hence the efficacy in these cases of administering mercurials (as blue pill or calomel) with diuretics. So also active cathartics sometimes augment the secretion of urine and aid the operation of diuretics by irritating the mouth of the ductus communis choledicus, causing an increased discharge of bile and pancreatic juice, and thereby relieving a congested state of the liver.

When the obstruction exists in the chest (heart or lungs), the operation of diuretics is aided by agents, such as digitalis, which tranquillize the action of the heart.

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[1] *Phil. Trans.* for 1842.

[2] *Guy's Hospital Reports*, Oct. 1844, p. 367.

Considered with reference to their chemical properties or to the nature and effects of their active principles, the diuretics may be arranged in the following groups:—

1. *Aqueous diuretics.*—Aqueous drinks promote diuresis indirectly, when the skin is kept cool, as I have before mentioned.

2. *Alkaline and saline diuretics.*—This group includes the alkalies and the alkaline and earthy salts.

The alkaline salts which contain a vegetable acid appear in the urine in the form of alkaline carbonates (see *ante*, pp. 179 and 180).

I have already stated that when saline substances are employed as diuretics they should be given in the form of dilute aqueous solution, as strong solutions act as cathartics. Liebig[1] states that the saline contents should be less than those of the blood, which contains from ¾ to 1 per cent. of chloride of sodium.

3. *Iodic and bromic diuretics.*—The iodic and bromic compounds are seldom used as diuretics.

4. *Mercurial and antimonial diuretics.*—Mercurials (especially blue pill, calomel, and bichloride of mercury) are frequently given in conjunction with the diuretics properly so called. They are useful by their influence over the portal circulation and as sorbefacients. Antimonials are seldom administered as diuretics.

5. *Acid diuretics.*—The dilute mineral acids sometimes act as diuretics (see *ante*, pp. 170—174). Dalton[2] found that vinegar diminished the secretion of urine.

6. *Sedative diuretics.*—This group includes tobacco and foxglove, whose power of reducing the force and frequency of the heart's action has been already referred to (see *ante*, p. 227). The diuretic effect has been referred, by Dr. Paris,[3] to their sedative operation. For, as the energy of absorption is generally in the inverse ratio of that of circulation, it is presumed that all means which diminish arterial action must indirectly prove diuretic by exciting the function of absorption. I have already explained how, in cardiac dropsy, foxglove may promote the diuretic effect of other substances (see *ante*, p. 252).

7. *Bitter acrid diuretics.*—To this group belong squills, colchicum, common broom, &c. These agents, in an over-dose, readily occasion vomiting. They owe their activity to an acrid principle, which operates, through the circulation, on the renal vessels as a local stimulant or irritant, and in this way proves diuretic. According to my own observations, common broom less frequently fails to prove diuretic than most other agents of this class.

8. *Acrid diuretics whose active principle is volatile oil.*—A considerable number of diuretics are referable to this group, as the cruciferous diuretics, buchu, copaiva, cajuputi, turpentine, juniper, and cantharides. The volatile oil is absorbed, and is carried by the blood to the kidneys, on which it acts topically as a stimulant.

9. *Alcoholic and ethereal diuretics.*—This group includes alcohol, wine, and nitric ether.

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[1] *Researches on the Motion of the Juices in the Animal Body*, Lond. 1848.

[2] *Memoirs of the Literary and Philosophical Society of Manchester*, 2d series, vol. v. Lond. 1831.

[3] *Pharmacologia*, 9th edit. p. 220, 1843.

Diuretics are employed for various purposes, of which the following are the principal:—

1. To restore the healthy action of the kidneys in diseases, generally in which the secretion of urine is diminished.

2. To promote the absorption of dropsical effusions. In most dropsies the renal secretion is diminished; and the obvious indication, therefore, is to augment this secretion in order not only to prevent further effusion, but also to promote the absorption of the fluid already effused. With this view diuretics are administered; but, as I have already observed, they frequently fail to augment the quantity of urine (see *ante*, p. 252). In the dropsy which follows scarlatina, the saline diuretics (especially nitrate of potash) with purgatives (jalap and bitartrate of potash) in general prove successful. In dropsy dependent on granular diseases of the kidney, diuretics (digitalis, colchicum, and cantharides) are, in the early period of the disease, of benefit. They should be preceded by, or alternated with, hydragogues (elaterium or jalap and bitartrate of potash), diaphoretics (Dover's powder), and warm-bathing. With the exception of warm-bathing, the same plan may be adopted for the relief of dropsy arising from cardiac disease.

3. To promote the elimination of poisonous agents from the system (see *ante*, p. 159).

4. To augment the elimination of water, and thereby to enable the urine to keep in solution the solid constituents of this secretion, as well as to act as a solvent for calculi contained in the urinary organs (see *Lithica*).

5. To relieve inflammatory action. Saline diuretics form part of the antiphlogistic treatment employed in inflammation.

2. *Diminishing secretion.*

(Sistentia; Reprimentia; Cohibentia; ἐπισχετικά.)

These are the remedies for fluxes. Considered with regard to the nature of their effect, they are of three kinds,—cerebro-spinals, astringents, and acrid stimulants.

a. Cerebro-spinalia.—Of the cerebro-spinal agents which check secretion, opium and its active principle morphia are the most powerful and constant in their effects. Opium checks all the secretions except that of the skin, which it promotes. Linnæus[1] excepts also the milk, menses, and lochiæ. Sprœgel[2] asserts that though opium checks the excretion of bile and urine, it does not diminish their secretion; for, in animals to whom he had administered opium, he found the ductus choledicus filled with bile, though the fæces, like those of jaundiced persons, were scarcely coloured; and the bladder filled with urine, although none had been passed for three days. But though opium checks the excretion of bile and urine, it undoubtedly also diminishes the secretion of these fluids.

Opium or morphia is employed to check profuse secretion in bronchial, gastric, intestinal, and renal fluxes; for example, catarrh, diarrhœa, diabetes, and hydruria. It is adapted for fluxes attended with an irritable condition of organs.

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[1] *Amœn. Acad.* viii. 298.

[2] Quoted by Dr. C. A. Christen (*Opium historice, chemice, atque pharmacologice investigatum*, Vindobonæ, 1820).

β. *Astringentia.*—The astringents employed for checking secretion include most of the topical astringents already mentioned (see *ante*, p. 158), the mineral acids (see *ante*, p. 170), and the astringent tonics (see *ante*, p. 209).

They act topically on the secreting organ—either directly, by application to the part, or indirectly, by absorption. They are most effectual when they are applied directly to the secreting organs (see *ante*, p. 158). They are much less so when applied to a distant part; for, though they become absorbed and are carried by the blood to the secreting organ, they undergo some chemical change in their passage by which their astringent influence is oftentimes considerably diminished.

The astringents check fluxes by their chemical influence over the tissues. They constringe the relaxed vessels. They are, therefore, adapted for asthenic fluxes attended with a weak or lax condition of the affected parts. They are employed in bronchial, gastric, intestinal, renal, urethral, and vaginal fluxes and in profuse perspiration. In bronchorrhœa, the most frequently employed astringents are the sulphate of zinc and acetate of lead; in pyrosis, the trisnitrate of bismuth; in diarrhœa and dysentery, the vegetable astringents (see *ante*, p. 209), acetate of lead, and sulphate of copper; in hydruria, sesquichloride of iron; in urethral and vaginal fluxes, the preparations of iron and zinc; in profuse perspiration, sulphuric acid; in cystorrhœa, uva ursi.

γ. *Stimulantia.*—The acrid stimulants used for checking secretion belong to the ethereal-oily and the resinous stimulants before noticed (see *ante*, pp. 219 and 222). Volatile oil and resin are their active constituents. These become absorbed, and are carried by the blood to the secreting organs, on which they exercise their influence.

The stimulants are employed to check secretion from the mucous surfaces in asthenic fluxes originating from inflammation; though sometimes, instead of curing the disease, they augment irritation and inflammation. In what way they operate as remedies for fluxes is very uncertain. Dr. Williams[1] thinks that "it is probably in removing congestions by causing determination of blood, which excites contraction, and improved tone of the capillaries of the part." (See *Repellents, ante*, p. 159.)

The acrid stimulants are more likely to prove beneficial in repressing secretion when the irritation or congestion is slight; but when this is violent, or when inflammation is present, they are apt to aggravate the malady.

In diarrhœa, the aromatics (see *ante*, p. 221) are used to check secretion; in bronchorrhœa, balsams of copaiba and Peru; in gonorrhœa and leucorrhœa, cubebs, balsam of copaiba, the terebinthinates, and cantharides; in cystorrhœa, buchu.

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[1] *Principles of Medicine*, 2d edition, p. 236, Lond. 1848.—Dr. Williams (p. 198) observes that "the influence of stimulants on congestion may be illustrated by the microscope. A solution of capsicum applied to a frog's web, congested after previous irritation, causes an enlargement of the arteries, an increased flow of blood; and, in some instances, causes the vessels to contract afterwards to their natural size, so that the congestion is completely removed: in that case the cure is complete. In other instances, however, the stimulants fail to clear the congested vessels: the enlarged arteries pour in more blood; but this, not overcoming the obstruction, increases the hyperæmia, and, as we shall afterwards see, may convert it into inflammation. Thus it appears that stimulants as well as astringents, though occasionally proving remedies for congestion, sometimes tend to increase it."

3. *Altering the quality of the secretions.*

(Eccritica alterantia vel alloiotica.)

It is but seldom that our sole object, in affecting the secretions, is that of altering their quality: usually we also desire to augment or lessen them; and the agents which do this likewise produce a change in the quality of the secretions.

We endeavour to alter the quality and improve the condition of the secretions in all diseases in which these present a morbid character; and we usually attempt this by agents which likewise augment the secretion.

But the altered condition of the secretions in some cases gives rise to certain inconveniences and secondary disorders, the prevention or relief of which is the special object of the agents which are administered to alter the quality of the secretions. It is frequently an indication to attenuate the secretions and to render them more fluid. Thus we endeavour to effect this in bronchial affections when the mucus is very viscid and clogs up the tubes; in acne punctata, in which the thick sebaceous matter accumulates in the follicles and gives rise to induration and suppurative inflammation; and when there is reason to suspect the existence of inspissated bile or a gall-stone.

In most of these cases we employ agents which increase, as well as alter the quality of, the secretions.

The only order of alterative eccritics which it will be necessary to notice separately is one including agents employed to modify the qualities of the urine for the relief of stone and gravel.

ORDER 9. LITHICA (λιθικά; from λίθος, *a stone* or *urinary calculus*). Medicines for the stone and gravel.—Under the name of *lithics* are included medicines which counteract the predisposition to the formation of urinary calculi, or which are employed with the view of effecting the solution or disintegration of urinary concretions within the body.

Medicines "which counteract the predisposition to the formation of calculous concretions in the urinary organs" are called by Dr. A. T. Thomson,[1] *antilithics* (*antilithica*).

Solvents for the stone are usually denominated *lithontriptica* or (more correctly) *lithonthryptica* (from λίθος, *a stone* or *urinary calculus*, and θρυπτικός, from θρύπτω, *I break* or *crush*). Pliny[2] terms them *saxifraga* (from *saxum*, a stone, and *frango*, I break). They might with more propriety be termed *lithonlytica* (from λίθος and λύω, *I dissolve* or *break up*).

The constituents of urinary concretions, for the prevention or removal of which lithics are administered, are the following:—

Lithic or uric acid.
Lithate of ammonia.
Oxalate of lime.
Cystic oxide.
Xanthic oxide.
Carbonate of lime.
Phosphate of lime.
Phosphate of magnesia and ammonia.

The following is a list of medicinal agents used as lithics:—

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[1] *Elements of Materia Medica and Therapeutics.*

[2] *Historia Naturalis*, lib. xxii. cap. 30.

VEGETABLE.

PAPAVERACEÆ.
Papaver somniferum—*Opium*.
ROSACEÆ.
Alchimilla arvensis—*Herba*.
UMBELLIFERÆ.
Daucus Carota—*Fructus*.

ERICACEÆ.
Arctostaphylos Uva Ursi—*Folia*.
URTICACEÆ.
Parietaria officinalis—*Herba*.
CONIFERÆ.
Pinus; plurimæ species—*Terebinthina*.

Astringentia vegetabilia } (see *ante*, p. 209-10).
Amara vegetabilia }
Acida vegetabilia (see *ante*, pp. 170—175).

Acidum benzoicum (see *ante*, p. 172).
Acidum cinnamicum.
Acidum malicum.

INORGANIC.

Aqua.
Acida mineralia (see *ante*, pp. 170—175).
Acidum carbonicum.
Alkalina (see *ante*, pp. 176—178).
Sapo.
Lithiæ carbonas.

Borax.
Sodæ phosphas.
Salia neutra vegetabilia (see *ante*, pp. 178—182).
Plumbi nitro-saccharas.
Aquæ minerales (*Malvern*; *Vichy*).

Diuretica (see *ante*, p. 250).

In the treatment of lithiasis two objects require attention: one is the prevention of calculous depositions within the body; and the other is the removal of the already deposited matter. The second object is attempted by means, some of which are medical, others surgical: the latter will of course not require notice here.

The preventive treatment of lithiasis varies somewhat according to the chemical nature of the urinary deposit; but in a general way it may be said to consist in a strict attention to diet and regimen, the promotion of the cutaneous functions, the regulation of the condition of the stomach and bowels, and the employment of lithics or medicines which, by their special influence over the urinary organs and the urine, prevent the formation of urinary deposits.

Lithics, considered with reference to their influence over the urine, are of three kinds,—diuretics, alteratives, and solvents.

1. *Diuretic lithics.*—Medicinal agents which possess a diuretic quality have long been celebrated in the treatment of stone and gravel.

In some cases they appear to act by increasing the quantity of water secreted by the kidneys, and thus, by rendering the urine more dilute, enable this secretion to retain in solution its solid constituents. In other cases they appear to give relief by promoting the secretion of lithic acid,[1] which, in some cases, appears to act as a sort of *materies morbi* (Prout). In this way Dr. Prout[2] thinks that "the good effects long ascribed to certain remedies of the active diuretic kind may be probably explained; such remedies appearing to possess the power, when given in favourable conditions of the system, of exciting the kidneys to separate large quantities of lithic acid; and in this way, by bringing about an artificial crisis, to produce great and immediate benefit."

The efficacy, in the lithic acid diathesis, of a mixture of turpentine and opium,[1] of muriatic acid and opium,[2] of the fruit (commonly called seeds) of the wild carrot, of the parsley breakstone (*Alchimilla arvensis*), of spiritus ætheris nitrici, of spiritus juniperi compositus, &c., may thus be in part explained. The beneficial effect of colchicum in gout has been ascribed to its causing the secretion of lithic acid.

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[1] The existence of lithic acid in the blood in gout, and its diminution or absence in the urine immediately preceding the gouty paroxysm, has been recently proved by Dr. Garrod (*London Medical Gazette*, Feb. 25, 1848).

[2] *On the Nature and Treatment of Stomach and Urinary Diseases*, 3d edit. p. 227, 1840.

2. *Alterative lithics.*—These are agents which alter the chemical qualities of the urine, and thereby prevent the formation of urinary deposits.

Some of them affect the urine by a direct chemical agency; that is, they become absorbed, are eliminated in the kidneys, and thus directly alter the chemical properties of the urine (see *ante*, p. 101). The alkaline and saline lithics act, in part at least, in this way; as do probably the acids also. Dr. Prout[3] states that "fluids containing the malic acid seem to possess peculiar powers in arresting the deposition of the phosphates in some individuals." Hence the beneficial influence, in many instances, of cider and perry. To this acid he also ascribes the solvent powers of Alchimilla arvensis.[4]

Some, on the other hand, indirectly alter the chemical qualities of the urine by the changes they effect in the vital processes of the animal economy. They modify the primary or secondary assimilation processes either by their influence over the nervous system or otherwise. Opium and vegetable bitters oftentimes prove beneficial in deposits of the triple phosphates: the former allays nervous irritation; the latter is calculated to relieve debility.

3. *Lithonlytics; Lithonthryptics* or *Lithontriptics; Solvents for the stone.*—These have been employed in two ways—viz. by the mouth and by injection into the bladder.

a. Lithonlytics by the mouth.

"A perfectly healthy condition of the urine," says Dr. Prout,[5] "is not only one of the most natural, but probably also one of the most powerful solvents for all the ingredients likely to exist in urinary calculi that we can hope to possess. So satisfied am I of the general truth of this remark, that my belief is, that there is scarcely any form of stone that would long bear the continued action of healthy urine without becoming more or less dissolved or disintegrated." Admitting this to be true, it follows that the most rational mode of effecting the solution of urinary calculi is by promoting the copious secretion of healthy urine.

In health the transparency of the urine is scarcely affected by the cooling of this liquid, a few nebulæ of mucus being alone deposited. When, however, the solid constituents of this secretion exist in an absolute or relative excess, the urine is either turbid when [illegible] or becomes so on cooling. It is obvious, therefore, that in the latter state it is unfitted for acting as a solvent of urinary calculi, as it is already saturated. In such cases water becomes a valuable agent. It dilutes the urine, and enables it not only to retain in solution, on cooling, the ordinary constituents of this secretion, but to act as a solvent of calculi. Hence, then, a copious use of aqueous fluids is an indispensable adjuvant of all lithontriptics. Even the long-continued action of large quantities of simple water on urinary calculi is capable apparently of disintegrating, and, in some cases, of dissolving them.[1]

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[1] Dr. Henry (*Med.-Chirurg. Trans.* vol. x. p. 136) says that a remedy apparently composed of turpentine and laudanum has sometimes brought away several ounces of lithic acid in the course of a day or two.

[2] Opium is useful in these cases "not only on account of its sedative properties, but from the property which it likewise possesses of increasing the secretion of lithic acid." (Prout.) When the lithic acid is disposed to come away in the form of gravel, Dr. Prout advises the use of a combination of muriatic acid and opium; but when it is disposed to concrete he substitutes the liquor potassæ for the acid.

[3] *Op. ante cit.* p. 283.

[4] *Philosophical Transactions* for 1843, p. 8.

[5] *Op. ante cit.* p. 452.

Bourchardat[2] asserts that water is the best lithonthriptic, and states that great water-drinkers are never afflicted with urinary calculi. He also insists "that lithontriptics are in general really and surely useful only when the urine remains limpid on cooling."

The great majority of agents employed as solvents for the stone are either acid or alkaline: the former being employed in phosphatic deposits; the latter in the lithic acid diathesis. But as healthy urine contains no free and uncombined alkaline or acid ingredient, Dr. Prout concludes that lithonlytics "are to be sought for among a class of harmless and unirritating compounds, the elements of which are so associated as to act at the same time with respect to calculous ingredients, both as alkalies and acids."

At present no substance of this kind is known; but the solutions of the super-carbonated alkalies, containing a great excess of carbonic acid, approach the nearest to them.

These are used in two forms, either as natural mineral waters or as artificial soda and potash waters. Of the latter, "the potash matters are preferable; and when the calculus is of the lithic acid variety, and the diathesis decided, from ʒss. to ℥j. of the carbonated alkali, and as much of the tartarized soda, may be dissolved in each bottle, which may be taken twice a day with an equal quantity of warm distilled water. On the other hand, when the concretions consist of the phosphates, and the urine is decidedly alkaline, the alkali may be omitted altogether, and the compound may either consist of distilled water impregnated with carbonic acid gas, or occasionally some acid, as the nitric, may be substituted for the alkali" (Prout).

Of the natural mineral waters those of Vichy[3] have been most noted for the cure of stone and gravel. They contain super-carbonate of soda, and, when taken internally, render the urine alkaline. The Malvern water,—principally by its purity, partly also by the minute quantity of alkali which it contains,—is useful in lithic acid deposits.

Lime-water and soap have been much celebrated as solvents for urinary calculi.[4] They are the chief active ingredients in Miss Joanna Stephens's *Receipt for the Stone and Gravel.*[5] Notwithstanding the favourable reports to the contrary,[1] it appears to me that no rational ground of hope can now be entertained that lime-water is capable of dissolving urinary calculi in the kidneys or bladder; but there is abundant evidence to prove that patients afflicted with the uric acid diathesis have sometimes experienced extraordinary benefit from its use.[2] Chevallier[3] accounts for its efficacy in the treatment of gravel and stone by the circumstance of the combination of the lime with uric acid forming a very soluble salt, viz. urate of lime; and he even thinks that lime-water may be useful in phosphatic calculi, either by depriving them of a portion of the uric acid which they contain, and thus rendering them less dense; by decomposing the ammoniacal salt which enters into the composition of some; or by acting on the animal matter which holds the molecules of these calculi together.

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[1] Chevallier, *Essai sur la dissolution de la gravelle et des calculs de la vessie.* Paris, 1837; also, *Lond. Med. Gaz.* vol. xx. p. 431.

[2] *Nouveau Formulaire Magistral,* p. 224. 3me édit. 1845.

[3] These waters, which were vaunted as solvents for stone by M. Petit, have of late years been the subject of numerous discussions among French physicians (see *Bulletin de l'Académie Royale de Médecine,* t. v. p. 60, for 1840; also, *British and Foreign Medical Review* for October 1841). "At the present time," says M. Mérat (*Supplément au Dictionnaire Univ. de Matière Médicale,* p. 736, 1846), "the patients at Vichy are divided into two parties: one, consisting of the gouty invalids, under the direction of M. Petit, who have faith in the waters; the other, under that of M. Prunellé, who are afraid of them. We believe," adds M. Mérat, "that M. Petit has given up his notions about the solution of gravel and calculi, and that he now holds the same opinion as his master [M. Prunelle], that the Vichy waters merely cause the expulsion of urinary concretions."

[4] See Dr. Whytt's *Essay on the Virtues of Lime-Water and Soap in the Cure of the Stone,* Edinb. 1752.—He relied on about an ounce of Castile soap and two or three pints of lime-water in the course of twenty-four hours.

[5] As this lady acquired no slight fame by her mode of treatment, a great desire was manifested

Borax and phosphate of soda are other lithonlytics which have been used in consequence of their solutions acting as good solvents for lithic acid.

The acids likewise have been used to modify the renal secretion. Though they are secreted by the kidneys in combination with a base (see *ante*, p. 173), and do not, therefore, react in the urine as free acids, yet they are occasionally useful in calculous complaints.

In conclusion it may be observed, that while in several instances marked benefit and relief has been obtained by substances administered by the mouth under the name of lithonthryptics, no confidence can be placed in the solvent powers of any agent hitherto employed. The relief obtained in several instances has been derived, not from the solution of the calculi, but from the diminution of pain and irritation in the urinary organs.

It deserves also to be noticed that all the medicines which are reported to have been successfully administered by the mouth for the solution of urinary calculi, belong to the class of alkaline substances; and that the secret of their success seems to have been their plentiful dilution with aqueous liquids. Provided this be attended to it is probable that the carbonated alkalies are as good lithonlytics as the caustic alkalies, while they are much less obnoxious to the digestive organs.

β. Lithonlytics injected into the bladder.—The direct and certain mode of bringing solvents in contact with calculi contained within the bladder is by injection. But the objection to this mode of proceeding is, that the introduction of chemical agents, sufficiently strong to exert much influence over the calculi, into the bladder, would be attended with dangerous irritation to the vesical coats. This plausible objection has not, however, in all cases

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to know the nature of her remedies, which she offered to discover on the payment of a suitable reward. A committee of professional men was appointed to examine the efficacy of her treatment, and her medicines were given to patients known to have calculi. The report made by the committee (*Gentleman's Magazine* for 1740, vol. x. p. 185) as to the effects was so favourable, that Parliament was induced to grant a reward of £5000, a notice of which appeared in the *London Gazette* of March 18, 1739! (D'Escherny, *A Treatise of the Causes and Symptoms of the Stone*, 1755.) The essential parts of her remedies were lime (prepared by calcining egg-shells and snails), soap, and some aromatic bitters, viz. camomile flowers, sweet fennel, parsley, burdock leaves, &c. (*Gentleman's Magazine* for 1739, vol. ix. p. 298). That the patients submitted to treatment obtained relief by the remedies employed cannot, I think, be doubted, but no cure was effected; that is, no calculus was dissolved, for in the bladder of each of the four persons whose cure was certified by the trustees, the stone was found after their death (Alston's *Lect. on the Mat. Med.* vol. i. p. 268, Lond. 1770).

[1] Chevallier, *Lond. Med. Gaz.* vol. xx. p. 460.

[2] Van Swieten's *Commentaries upon Boerhaave's Aphorisms*, vol. xvi. p. 299.

[3] *Lond. Med. Gaz.* vol. xx. p. 584.

been found to hold good. On the contrary, lithonlytic injections into the bladder have, in some instances, allayed irritation.

The substances which have been employed in this way are—lime-water, alkaline solutions, acid solutions, and a solution of nitro-saccharate lead. Mr. Ure[1] has proposed to employ a solution of carbonate of lithia.

In several instances lime-water has been introduced into the bladder without inconvenience; and, in one instance,[2] it appears to have been successful, as it is stated that no relic of the stone was left. In this case about five ounces of lime-water were introduced twice daily for ten weeks.

Alkaline solutions have also been used, and, in some cases, successfully. In one instance,[3] from three to six ounces of a solution of caustic potash, which hardly produced a feeling of warmth in the mouth at 98° Fahr., was introduced twice daily, and is said to have effected a perfect cure. In another case,[4] a solution of 115 grains of bicarbonate of soda to the wine pint of water rendered the fragments of an uric acid calculus so friable that very slight pressure was sufficient to break them.

Water, acidulated with hydrochloric, sulphuric, or nitric acid, has been tried in several instances, and, in some, with success. Sir B. Brodie[5] employed water acidulated with two or two and a half minims of nitric acid to every ounce of distilled water. The injection was used for from fifteen to thirty minutes every two or three days. The symptoms were relieved and a phosphatic calculus dissolved. In another case,[6] water containing a small portion of nitric acid (from $\frac{4}{100}$ths to $\frac{5}{100}$ths) has been injected with success.

More recently, Dr. Hosken[7] has used a solution of nitro-saccharate of lead.[8] The solution consisted of one grain of nitro-saccharate of lead "moistened with five drops of pure saccharic acid and dissolved in a fluid-ounce of distilled water." The liquid thus obtained was bland, without any astringency, but had a slight acid reaction. It decomposed phosphatic calculi, and caused the deposition of phosphate of lead. When injected into the bladder rendered morbidly irritable by the presence of stone, it was freely tolerated.

Even simple water injected into the bladder daily for several months has appeared to have partially dissolved and disintegrated a phosphatic calculus.[9]

On the whole, it is obvious that sufficient success has been obtained by the injection of lithonlytic liquids into the bladder to warrant further experiments and perseverance in this method of treatment.

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[1] *Pharmaceutical Journal*, vol. iii. p. 71. Carbonate of lithia is a constituent of several German mineral waters which have been found serviceable in affections of the urinary organs. One part of carbonate of lithia is soluble in 100 parts of water at 60° Fahr.

[2] W. Butter, *Method of Cure for the Stone, chiefly by Injections*, 12mo. Edinb. 1754.

[3] Ritter, in Hufeland's *Journal*, Bd. xxv.; also, *British and Foreign Medical Review*, vol. xii. pp. 399—400, 1841.

[4] *Comptes Rendus*, March 21, 1842.

[5] *London Medical Gazette*, June 18, 1831.

[6] *Comptes Rendus*, March 21, 1842.

[7] *Phil. Trans.* for 1848.

[8] Nitro-saccharate of lead was thus prepared. Pulverized saccharate of lead was dissolved in a sufficient quantity of cold dilute nitric acid (one acid to nineteen water). By filtration and gradual evaporation, amber coloured crystals of nitro-saccharate of lead were obtained.

[9] *British and Foreign Medical Review*, vol. xii. p. 400.

Class IX. *Genetica.* Medicines acting on the Sexual Organs.

Medicines which act on the sexual organs may be termed *genetica* (*γενετικά*; from *γείνομαι*, *I am begotten* or *I beget:* whence *γένεσις*, *origin*, *generation*).

This class includes the medicinal agents supposed to affect the venereal orgasm, and those which act on the uterus.

1. *Affecting the orgasm.*

The existence of medicinal agents endowed with specific aphrodisiac or anaphrodisiac powers has been denied by some, and admitted by others. Most modern systematic writers on pharmacology have agreed with Dr. Cullen[1] in the belief of the non-existence of agents of this kind; and, therefore, in recent works on Materia Medica, aphrodisiacs and anaphrodisiacs are, as distinct classes or orders, unnoticed.

But it appears to me that Dr. Cullen's opinion is scarcely supported by fact. That the sexual feelings and powers may be influenced directly or indirectly by substances taken into the stomach, cannot, I think, be doubted. The aphrodisiac property of phosphorus, for example, has been recognised both in man and the lower animals; and there is reason to believe that some other agents, as Indian hemp, act in the same way. The refrigerant and anaphrodisiac effects of nauseants and drastics are well known.

From time immemorial a belief has existed in the aphrodisiac and anaphrodisiac properties of certain dietetical and medicinal agents;[2] and though the popular opinion may be in many cases erroneous, there is reason to suspect that it has some foundation in fact. Such agents would probably prove more influential on the susceptible nervous system of inhabitants of warm than of cold climates.

In practice, cases not unfrequently occur in which aphrodisiac or anaphrodisiac agents are indicated, and in which medicinal substances are given with the view of producing the one or the other of these effects. It appears to me, therefore, that a brief enumeration of substances reputed to possess aphrodisiac or anaphrodisiac properties may not be uninteresting or useless.

ORDER 1. APHRODISIACA (*ἀφροδισιακά*; from *ἀφροδίσια*, *venery*).—Medicines which are supposed to excite the sexual feelings, or to increase the venereal powers, are called *aphrodisiacs*.

Various odoraments, as musk, castoreum, civet, and ambergris,[3] have been employed as sexual stimulants. Several intoxicating agents, especially wine, Indian hemp, and opium, have been used as aphrodisiacs; but it is doubtful whether any of them increase the sexual powers, though they may inflame the imagination and excite desire: wine is well known to diminish them. Nux vomica appears to be a sexual stimulant. Spices (see *ante*, p. 219); the alliaceous and cruciferous stimuli which contain the allyle oils (see

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[1] *Treatise of the Materia Medica*, vol. i. p. 171, Edinb. 1789.

[2] For a list of such substances, see Virey's memoir *Des Médicamens Aphrodisiaques en général, et en particulier sur le Dudaim de la Bible*, in the *Bullet. de Pharmacie*, t. v. p. 193. 1813.

[3] Prosper Alpinus (*De Medicina Ægyptiorum*, lib. iii. cap. xv.) states that the Egyptian women use unguents containing musk, ambergris, aloes, and civet, " ad coeuntibus voluptatem conciliandam."

ante, p. 220); some of the resinous stimulants, as the turpentines and the fetid gum-resins; phosphorus; cantharides; emmenagogues, as borax and aristolochia; the chalybeates; and certain dietetical substances, such as fish[1], shell-fish, salt, and leguminous seeds, are reputed aphrodisiacs, and some of them may, perhaps, under certain circumstances, occasionally act as such.

ORDER 2. ANAPHRODISIACA (*ἀναφροδισιακά*, from *ἀναφροδισία*, *absence of the sexual feelings*).—Medicinal agents which are supposed to take away or repress the sexual feelings are called *anaphrodisiacs* or *antaphrodisiacs*.

Nauscants (as emetic tartar) and drastic cathartics act as anaphrodisiacs. Carbonate of soda and soda water are also said to possess similar properties; as well as hemlock. Camphor has been long in repute as an anaphrodisiac; and by the school of Salernum it was said that "*camphora per nares castrat odore mares.*" Trousseau and Pidoux[2] experienced temporary anaphrodisia from 36 grains of this substance.

Many other substances are reputed anaphrodisiacs, but on insufficient evidence. Such are the aromatic labiate plants, coffee (which has been called *potus caponum*), cucurbitaceous plants, lettuce, &c. &c.

2. *Affecting the uterus.*

(Uterina.)

This division includes two orders of medicinal agents, *emmenagogues* and *ecbolics*.

ORDER 3. EMMENAGOGA (*ἐμμηναγωγά*, from *ἐμμήνια*, *the menstrual discharge*, and *ἀγωγός*, *eliciting* or *evoking*); *Menagoga.*—Medicines which excite or promote the catamenia are denominated *emmenagogues*.

As the suppression or retention of the catamenia may be occasioned by very different circumstances, no one agent can be expected to prove emmenagogue in all, or even in many cases. Deficient menstruation is rarely, perhaps, an idiopathic disease, but in general a morbid symptom merely; and therefore those agents which remove it must be relative, that is, must have reference to the disease which produces it.

When amenorrhœa coexists with anæmia, the most effectual emmenagogues are the chalybeates (see *ante*, p. 189). In most cases it will be found advisable to conjoin aloetic purges. In hysterical amenorrhœa unaccompanied by anæmia, ammonia, the fetid gum resins, castoreum, cubebs, &c., prove indirectly emmenagogue. Here also aloetic purges frequently prove serviceable. When amenorrhœa occurs in plethoric habits, blood-letting and active cathartics act indirectly as emmenagogues.

But the term emmenagogue is usually employed in a more limited sense,—namely, to indicate those substances which are supposed to possess a specific power of affecting the uterus, and thereby of promoting the catamenial discharge. There are, however, few bodies to which this definition can be strictly applied. Indeed, two reasons have led some pharmacological writers to doubt the existence of any medicines which can be properly termed specific emmenagogues,—namely, the uncertainty of all the means so named, and the uterus not being an organ intended for the excretion of foreign matters.

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[1] The popular notion that those who live principally on fish are unusually prolific, appears to be erroneous. (See my *Treatise on Food and Diet*, p. 282.)

[2] *Traité de Thérapeutique*, t. i. p. 48, Paris, 1836. These authors mention, as the characteristic of the anaphrodisia produced by camphor, "l'imperfection de l'erection."

The substances usually regarded as specific emmenagogues are, for the most part, medicines which, when taken in large doses, act as drastic purgatives. Such are savin, black hellebore, aloes, gamboge, &c. They excite the pelvic circulation, give rise to a sensation of bearing down of the womb, especially in females disposed to procidentia uteri, increase uterine hemorrhage or the menstrual discharge when given during these conditions, and, when administered in chlorosis or amenorrhœa, sometimes bring on the catamenia.

Stimulating diuretics extend their exciting influence by contiguous sympathy to the uterus, and thus often act as emmenagogues. Gin, which is frequently employed by females to excite the menstrual discharge, appears to act in this way. I have known abortion produced by cantharides given as an emmenagogue.

Rue is a reputed and popular emmenagogue. It possesses cerebro-spinal properties, and has on several occasions produced miscarriage.

Madder was a favourite emmenagogue with the late Dr. Home,[1] who declared it to be the strongest and safest known.

Stinking goosefoot or stinking orache (*Chenopodium olidum*) is not unfrequently used by females as an emmenagogue. It is sold by herbalists, and is in sufficient demand to induce the herb-growers at Mitcham to cultivate it.

Ergot of rye possesses an unequivocal influence over the uterus. But it rather promotes uterine contractions than the menstrual function, though it has on many occasions been successfully employed in amenorrhœa.

Borax is a stimulant to the uterus, and sometimes proves emmenagogue.

Mercurials and iodide of potassium promote the catamenia in common with the secretions generally.

Aristolochia was formerly in use as an emmenagogue.

ORDER 4. ECBOLICA (from ἐκβόλιον, *a medicine which causes abortion or the expulsion of the fœtus*); *abortiva*; *amblotica* (ἀμβλωτικά); *amblothridia* (ἀμβλωθρίδια).—Medicines which excite uterine contractions, and thereby promote the expulsion of the contents of the uterus, are called *ecbolics*.

Ecbolics are essentially distinguished from emmenagogues by this circumstance, that while the latter stimulate the vascular system of the uterus, the former excite the uterine muscular fibres. Ecbolics, therefore, promote the expulsion of substances contained in the uterine cavity; such as the fœtus, the placenta, hydatids, clots of blood, &c.

The number of ecbolics known is very small. Indeed the only unequivocal agent of this kind is ergot. The ergot in ordinary use is that of rye, but the ergot of wheat is equally effectual, and the same perhaps may be stated of the ergot of all grasses.

Borax is said to act as an ecbolic.

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[1] *Clinical Experiments*, p. 422, 2d edition, Lond.

DIV. II.—Special Pharmacology.

SPECIAL PHARMACOLOGY treats of medicines individually. These I shall arrange in two groups, called respectively the *inorganic* and the *organic*; the former of which will be sub-divided according to the chemical relations of its members, the latter according to their external, or, as they are usually termed, natural history characters.

Objections may be raised to this mixed system of classification; but in the present state of science, an arrangement founded exclusively either on external or on chemical characters, must be most unsatisfactory. Our knowledge is as yet too incomplete to allow us to follow either principle exclusively; and some of the most recent writers[1] on mineralogy admit the insufficiency of external characters for the determination of all mineral species. I cannot admit the propriety of limiting the term natural history characters to external properties only, and of excluding chemical characters from the means employed to distinguish natural bodies.[2] The best and most perfect classification would be obviously that which is founded on a consideration of *all* the properties.

The division of medicines into inorganic and organic is not free from objections or without difficulties; for there are some substances which might with equal propriety be referred to either group, since they are composed both of inorganic and of organic compounds.[3] Such are metallic salts composed of a metallic oxide and an organic acid. These bodies are usually referred to organic substances; but as in most cases their medicinal properties are allied to those of the inorganic salts of the same metals, it will be more convenient and natural for me to consider them among inorganic substances.

I. INORGANIC BODIES.

Of the *inorganic* or *anorganic* substances used in medicine some are simple, others are compound.

At the present time (May 1848) sixty-two[4] simple or elementary substances are known; and of these, thirteen are called non-metallic bodies and forty-nine are termed metals.

NON-METALLIC BODIES OR METALLOIDS.

1. Oxygen.
2. Hydrogen.
3. Carbon.
4. Boron.
5. Silicon.
6. Phosphorus.
7. Sulphur.
8. Selenium.
9. Iodine.
10. Bromine.
11. Chlorine.
12. Fluorine.
13. Nitrogen.

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[1] *Report on the Recent Progress and Present State of Mineralogy*, by W. Whewell, M.A. (In the *Report of the First and Second Meetings of the British Association*, Lond. 1833).—*A System of Mineralogy*, by J. D. Dana, A.M. p. 18, 2d edit. New York, 1844.

[2] Glocker, in his *Generum et Specierum Mineralium secundum Ordines Naturales digestorum Synopsis* (Halæ Saxonum, 1847), has arranged minerals in eighteen orders, which he calls *natural*, the characters of many of which are wholly chemical. These orders are contained in five classes exclusively founded on the chemical nature of the substances. It is obvious, therefore, that the author includes chemical properties among natural history characters.

[3] "Organic compounds," says Leopold Gmelin (*Handbuch der Chemie*, 4ter Bd. p. 4, 1848), "are simple compounds containing more than one atom of carbon." By the term simple compounds are meant those which cannot be formed of other compounds. Such substances as bicarbonate of potash are, therefore, obviously excluded.

[4] I have not included the newly announced metal called *ilmenium* in this number, some doubts

METALS.

14. Kalium.
15. Natrium.
16. Lithium.
17. Barium.
18. Strontium.
19. Calcium.
20. Magnesium.
21. Cerium.
22. Lanthanium.
23. Didymium.
24. Yttrium.
25. Terbium.
26. Erbium.
27. Glucinum.
28. Aluminum.
29. Thorium.
30. Zirconium.
31. Norium.
32. Titanium.
33. Tantalum.
34. Niobium.
35. Pelopium.
36. Tungsten.
37. Molybdenum.
38. Vanadium.
39. Chromium
40. Uranium.
41. Manganesium.
42. Arsenicum.
43. Antimonium.
44. Tellurium.
45. Bismuth.
46. Zinc.
47. Cadmium.
48. Tin.
49. Lead.
50. Iron.
51. Cobalt.
52. Nickel.
53. Copper.
54. Quicksilver.
55. Silver.
56. Gold.
57. Platinum.
58. Palladium.
59. Rhodium.
60. Iridium.
61. Osmium.
62. Ruthenium.

ORDER I. OXYGEN AND ITS AQUEOUS SOLUTION.

1. OXYGENIUM.—OXYGEN.

Symbol O. *Equivalent Weight* 8. *Equivalent Volume* 0·5 or □

HISTORY.—Oxygen gas was discovered on the 1st of August, 1774, by Dr. Priestley,[1] who denominated it *dephlogisticated air*. In the following year, Scheele also discovered it, without knowing what Priestley had done, and he called it *empyreal air*. Condorcet termed it *vital air*. Lavoisier named it *oxygen* (from ὀξύς, *acid*, and γεννάω, *I beget* or *produce*).

NATURAL HISTORY.—Oxygen is found in both kingdoms of nature.

a. IN THE INORGANISED KINGDOM.—Oxygen is, of all substances, that which is found in the largest quantity in nature, for it constitutes at least three-fourths of the known terraqueous globe. Thus water contains eight-ninths of its weight of oxygen; and the solid crust of our globe probably consists of at least one-third part, by weight, of this principle; for silica, carbonate of lime, and alumina—the three most abundant constituents of the earth's strata—contain each about half their weight of oxygen. Sir H. De la Beche[2] calculates that silica alone constitutes "forty-five per cent. of the mineral crust of our globe." Of the atmosphere, oxygen constitutes twenty or twenty-one per cent. by volume, or about twenty-three per cent. by weight, to which must be added eight-ninths, by weight, of the atmospheric aqueous vapour.

β. IN THE ORGANISED KINGDOM.—Oxygen is an essential constituent of all living bodies. It is disengaged by plants and absorbed by animals. The former obtain it by the decomposition of water and carbonic acid; the latter consume it in the oxidisement of hydrogen and carbon, and the consequent formation of water and carbonic acid. Thus the two kingdoms of the organised world bear an important relation to each other. Vegetables may have been the original producers of atmospheric oxygen, as they are now the purifiers of the air. In the sun's rays they absorb carbonic acid, decompose it, retain the carbon, and emit the oxygen.

PREPARATION.—There are several methods of procuring this gas:—

1. *By heating chlorate of potash.*—This method yields pure oxygen gas. Theoretically 100 grs. of chlorate should evolve 39·183 grs. (=114·6 cub. inches at 60° F. and 30′ bar.) of pure oxygen gas. (From 100 grains of the chlorate we may expect to obtain nearly 100 cubic inches of the gas.

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having been raised by H. Rose as to the reality of its existence. (See Poggendorff's *Annalen*, Bd. lxix. p. 115. 1846).

[1] *Experiments and Observations on different kinds of Air*, vol. ii. p. 106, Birmingham, 1790.

[2] *Researches in Theoretical Geology*, p. 8, Lond. 1834.

—*Brande.*) One equivalent of chlorate of potash yields six equivalents of oxygen and one equivalent of chloride of potassium. $KO, ClO^5 = KCl + O^6$.

MATERIAL.	COMPOSITION.		PRODUCTS.
1 eq. Chlorate of Potash... 122·5	1 *eq. Chloric Acid* 75·5	5 *eq. Oxygen*... 40	6 eq. Oxygen 48
		1 *eq. Chlorine* . 35·5	
	1 *eq. Potash* 47	1 *eq. Oxygen*... 8	
		1 *eq. Potassium* 39	1 eq. Chloride Potassium 74·5
	122·5	122·5	122·5

The process is greatly facilitated by intimately mixing the powdered chlorate with from $\frac{1}{10}$ to $\frac{1}{4}$ of its weight of powdered binoxide of manganese. A very moderate heat is then sufficient to cause the decomposition of the chlorate and the evolution of oxygen gas. The mixture soon begins to glow, and the gas is given out with great rapidity. The binoxide appears to act mechanically and by contact, like iron filings in facilitating the boiling of water; for it does not necessarily undergo any chemical change during the process; and other substances, as oxide of copper, may be substituted for it.

As thus modified this is by far the most convenient of the different methods of preparing oxygen gas. The process may be conducted in a glass retort or flask to which a bent tube is adapted by means of a perforated cork. Retorts or flasks made of glass without lead are to be preferred. A spirit or oil lamp is used to heat the mixture.

2. *By heating binoxide of manganese in an iron bottle.*—This is the cheapest method; and, for ordinary purposes, it yields oxygen gas sufficiently pure. The common black oxide of manganese of commerce, called by mineralogists *pyrolusite*, is an impure binoxide. When subjected to heat, it first evolves water in the form of steam, frequently carbonic acid (from the presence of an earthy carbonate), and afterwards oxygen gas. To remove traces of carbonic acid, the gas may be washed with lime-water or a solution of caustic potash; but if the first products be allowed to escape, this proceeding is unnecessary. One of the malleable iron bottles in which mercury is imported from Spain may be conveniently employed for igniting the oxide, a piece of curved iron gas tubing being screwed into it.

By heat the binoxide loses part of its oxygen, and becomes converted into the sesquioxide. $2Mn\,O^2 = O + Mn^2\,O^3$. By a stronger heat a portion of the sesquioxide is converted into protoxide, leaving a compound of sesquioxide and protoxide. The conversion of binoxide into this compound may be thus expressed: $3Mn\,O^2 = 2O + Mn^2\,O^3, Mn\,O$.

MATERIAL.	PRODUCTS.	
3 eq. Binoxide Manganese = 132	2 eq. Oxygen	16
	1 eq. Sesquioxide Manganese ...	80
	1 eq. Protoxide Manganese......	36
		132

As 132 grs. of pure binoxide yield 16 grs. of oxygen, 1 ℔. avoirdupois will yield about 848½ grs. or 71½ imperial pints. One pound of common commercial black oxide usually yields from 30 to 40 pints; but, from fine samples, from 40 to 50 pints may be procured.

The preceding are the usual methods of procuring oxygen. The following are other modes of obtaining it, but they are seldom resorted to.

1. By heating the black oxide of manganese with its own weight of oil of vitriol in a glass retort. The products are sulphate of the protoxide of manganese, water, and oxygen, $Mn\ O^2 + HO,\ SO^3 = Mn\ O,\ SO^3 + HO + O$.

2. By heating three parts of powdered bichromate of potash with four parts of oil of vitriol in a glass retort.[1] The products are sulphate of potash, sulphate of the sesquioxide of chromium, water, and oxygen, $KO,\ 2Cr\ O^3 + 4\ (HO,\ SO^3) = KO,\ SO^3 + Cr^2\ O^3,\ 3SO^3 + 4HO + 3O$.

3. By igniting the red oxide of mercury. The products are metallic mercury and oxygen.

4. By igniting nitrate of potash. The products are hyponitrite of potash and oxygen, $KO,\ NO^5 = KO,\ NO^3 + 2O$.

PROPERTIES.—It is elastic, colourless, odourless, tasteless, incombustible, but a powerful supporter of combustion. According to Regnault, 100 cubic inches of this gas weigh, at the temperature of 60° F., and when the barometer stands at 30 inches, 34·19 grains: and its specific gravity is 1·1056. (According to Berzelius and Dulong, the sp. gr. is 1·1026.)

Characteristics.—Free oxygen gas, either pure or in a gaseous mixture, is recognised by the following characters:—

α. When binoxide of nitrogen is mingled with it, yellowish or ruddy fumes of hyponitric acid are produced.

β. When mixed with twice its volume of hydrogen, and the mixture is exploded in the eudiometer, water only is the product. The diminution of volume divided by 3 indicates the amount of oxygen present.

Oxygen gas, when absolutely or tolerably pure, rekindles a wood match or taper, which is red with heat but without flame. The only gas likely to be confounded with oxygen in this respect is the protoxide of nitrogen, from which oxygen is distinguished by the characters above mentioned.

The presence of free oxygen in mineral waters is detected by the sulphate of the protoxide of iron. A bottle being nearly filled with the water, a solution of this salt is to be added and the vessel immediately stopped, care being taken that every bubble of air be excluded. If oxygen be present a yellowish-brown precipitate (sesquioxide of iron) is produced. Some persons add a few drops of liquor potassæ to the mixture: if no free oxygen be present, a bluish precipitate (hydrated protoxide of iron) is formed; but if there be oxygen, a yellowish-brown precipitate (sesquioxide of iron) occurs.

Combined oxygen is recognised thus. The oxides of the noble metals are reduced by heat, oxygen gas being set free. The oxides of the ignoble metals, when mixed with carbon and ignited, are reduced, carbonic oxide or carbonic acid being evolved. Every volume of carbonic oxide contains half a volume of oxygen, and every volume of carbonic acid its own volume of oxygen. The oxides of potassium and sodium are also reduced by carbon and heat, carbonic oxide being evolved. Potassium decomposes (either at common temperatures or at a red heat) most compounds containing oxygen, and becomes converted into potash; and it is sometimes useful for detecting the presence of oxygen. In organic analysis, the amount of oxygen contained in the organic substance is estimated from the loss, and is, therefore, liable to fallacy.[2]

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[1] Balmain, *Pharmaceutical Journal*, vol. ii. p. 92.

[2] To illustrate the nature of the fallacy alluded to in the text, the analysis of cystic oxide may be

PHYSIOLOGICAL EFFECTS. *a. On Vegetables.*—Oxygen gas is essential to the germination of seeds and to the existence and growth of plants. Edwards[1] says that seeds in germinating decompose water to obtain oxygen. In the shade, vegetables absorb it from the atmosphere and evolve an equal volume of carbonic acid; while, in the solar rays, the reverse changes take place, carbonic acid being absorbed and oxygen expired. The vigorous growth of plants in inclosed cases, as originally proposed and practised by my friend Mr. N. B. Ward,[2] does not invalidate the above statements; since the cases are never completely air-tight, but allow the ingress and egress of air consequent on changes of temperature. The quantity of oxygen required for the growth of some plants, however, appears to be much smaller than was previously supposed.

The effects of pure oxygen gas on germination and vegetation have been examined by Theod. de Saussure.[3] He found that the period of germination is the same in oxygen gas as in atmospheric air, but that seeds evolve more carbonic acid in the former than in the latter. Plants do not thrive so well in an atmosphere of oxygen gas in the shade as in one of common air; they give out more carbonic acid, which is always injurious to vegetation in the shade. When exposed in oxygen gas to the direct rays of the sun, they augment in weight about as much as in atmospheric air.

β. On Animals generally.—It is usually asserted that all animals require the influence of oxygen, or rather of air, to enable them to exist; but this assertion cannot be proved in the case of some of the lower animals. Thus intestinal worms seem to dispense with respiration.[4] Some animals which respire have no organs especially devoted to this function: in these the cutaneous surface effects respiration; as in the *Polypifera*. In the *Infusoria* the respiratory organs are delicate cilia. Many animals have branchiæ, or gills, for respiration, as some *Mollusca*, some *Annelida*, and fishes. Leeches respire by subcutaneous sacs, which open externally. The respiratory organs of insects are ramifying tracheæ. Lastly, the higher classes of animals, as the Mammals, respire by means of lungs. Whenever respiration is effected, a portion of oxygen disappears, while a quantity of carbonic acid, nearly equal in volume to the oxygen consumed, is produced.

The continued respiration of oxygen gas is injurious, and even fatal to animal life: this has been observed by all experimenters. Animals live

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quoted. This organic substance was analysed by Dr. Prout (*Med. Chir. Trans.* vol. ix. p. 480), who found that it contained in 100 parts

Carbon	29·875
Hydrogen	5·125
Nitrogen	11·850
	46·850
Deficiency	53·150
	100·000

He therefore placed the deficiency to the account of oxygen. Now it has been more recently ascertained by Thaulow (*Ann. der Chem. u. Pharm.* xxvii.), that about one half of this deficiency is due to sulphur.

[1] *Athenæum*, Feb. 2, 1839.

[2] *Companion to the Botanical Magazine, for May*, 1836.

[3] *Recherches Chimiques sur la Végétation*, pp. 11, 12, and 93, Paris, 1804.

[4] Müller's *Physiology*, by Baly, vol. i. p. 295.

longer in a given volume of oxygen than in the same quantity of atmospheric air, but the continued employment of it causes death. Mr. Broughton confined rabbits, guinea-pigs, and sparrows, in glass jars containing oxygen, and inverted over water. At first they suffered no inconvenience, but in about an hour their breathing became hurried and the circulation accelerated. This state of excitement was followed by one of debility; the respirations became feeble, and were more slowly performed; loss of sensibility and of the power of voluntary motion supervened, till the only remaining visible action was a slight one of the diaphragm, occurring at distant intervals. On opening the body, the blood (both venous and arterial) was found to be of a bright scarlet hue; it was thin, and rapidly coagulated. The gas in which animals had thus been confined till they died, retained its power of rekindling a blown-out taper, and of sustaining for a time the life of another animal introduced into it; and Mr. Broughton hence deduced the inference that it does not contain so great an excess of carbonic acid as the gas left when animals have perished by confinement in atmospheric air; and he considered the train of symptoms induced by the respiration of pure oxygen gas as analogous to those which follow the absorption of certain poisons into the system.[1] Injected into the pleura, oxygen gas is very quickly absorbed, without producing inflammation. Cautiously injected into the veins of dogs, it has no sensible effect on the system.[2]

γ. *On Man.*—If pure oxygen be inspired a few times it does not produce any remarkable phenomena; though some have ascribed various effects to it, such as agreeable lightness in the chest, exhilaration, increased frequency of pulse, a sensation of warmth in the chest, gentle perspiration, and an inflammatory state of the system. But several of these results arise probably from mental influence, others from the mode of inhaling the gas, and perhaps some might depend on the employment of impure oxygen.

USES.—Soon after the discovery of oxygen, the most exaggerated notions prevailed as to its remedial powers. Various diseases (scorbutus, for example) were thought to be dependent on a deficiency of it; and it was, in consequence, submitted to a considerable number of trials, with, as it was at first asserted, remarkable success. But Chaptal[3] and Fourcroy[4] declared that it was injurious in phthisis. In England it was tried by Beddoes[5] and Hill.[6] The latter states that he found it beneficial in asthma, debility, ulcers, gangrene, white swelling, and scrofulous diseases of the bones. The beneficial results obtained by the use of acids (especially nitric acid), of the oxides of mercury, chlorate of potash, vegetable food, &c. were referred to the oxygen which these substances contained, and which they were supposed to communicate to the system. These notions are now exploded.[7]

In asphyxia arising from a deficiency of atmospheric air or from breathing noxious vapours, the inhalation of oxygen gas has been said to be, and probably is, useful. On the same principle, it may be employed during an attack of spasmodic asthma when there is danger of suffocation; but it is at best only a palliative, and has no power of preventing the occurrence of other attacks. Chaussier[1] has recommended its use in children apparently still-born: I have known it used without benefit. To combat the asphyxia of malignant cholera, inhalations of oxygen were tried in Russia, Poland, Prussia, and France, but without success.[2] On the whole, then, I believe oxygen to be almost useless as a remedy.[3]

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[1] *London Medical Gazette*, vol. iii. p. 775.

[2] Nysten, *Recherches de Physiologie*, p. 60, Paris, 1811.

[3] *Annales de Chimie*, t. iv. p. 21.

[4] *Ibid.* t. iv. p. 83.

[5] *Considerations on the Medicinal Use of Factitious Airs, and on the Manner of obtaining them in large Quantities.* By T. Beddoes and James Watt. Bristol, 1794—1795.

[6] *Practical Observations on the Use of Oxygen, or Vital Air, in the Cure of Diseases*, Lond. 1800.

[7] For further details respecting these opinions, see the *Dictionnaire Universel de Matière Médicale et de Thérapeutique Général*, par F. V. Mérat and E. J. De Lens, t. v. p. 136.

AQUA OXYGENII. *Oxygen Water.*—At the mean pressure and temperature of the atmosphere, 100 vols. of water dissolve, according to Dalton and Henry,[4] 3·7 vols. of oxygen gas; according to Saussure,[5] 6·5 vols. By pressure in a proper machine, water may be charged with a much larger quantity. This solution has been termed *oxygenated water*, but is a very different substance to the peroxide of hydrogen, which has also been known by this appellation (see *Hydrogenii binoxydum*). Neither is it to be confounded with Searle's *oxygenous aërated water*, which is an aqueous solution of the protoxide of nitrogen (see *Aqua nitrogenii protoxydi*). It has been used to the extent of one or two bottlefuls daily, as a slight excitant. It is said to increase the appetite and promote the secretions, and to be serviceable in spasm of the stomach, amenorrhœa, hysteria, atonic dropsy, &c.

Order II. HYDROGEN AND ITS COMPOUNDS WITH OXYGEN.

Two compounds only of hydrogen with oxygen are known: namely, the *protoxide of hydrogen* or *water*, HO; and the *binoxide of hydrogen*, HO^2.

2. HYDROGENIUM.—HYDROGEN.

Symbol H. *Equivalent Weight* 1. *Equivalent Volume* 1 or □

History.—Cavendish,[6] in 1766, may be considered as the real discoverer of hydrogen, though it must have been occasionally procured, and some of its properties known, previously. He termed it *inflammable air*. Lavoisier called it hydrogen (from ὕδωρ, *water*, and γεννάω, *I beget* or *produce*), because it is the radicle or base of water.

Natural History.—It is found in both kingdoms of nature.

a. In the Inorganised Kingdom.—Next to oxygen, it may be regarded as the most important constituent of the terraqueous globe. It constitutes 11·1 per cent. by weight of water. It is an essential constituent of some minerals (as coal, amber, and sal ammoniac), in which it does not exist as an element of water. The gas which is contained in the decrepitating rock salt of Wieliczka, in a very condensed state, is a mixture of hydrogen, carbonic oxide, and light carburetted hydrogen: the salt decrepitates when placed in water, owing to the disengagement of these gases. Lastly, it is evolved from volcanoes, or from fissures in the earth, in combination with carbon, sulphur, chlorine or nitrogen, under the forms of light carburetted hydrogen, sulphuretted hydrogen, hydrochloric acid, and ammonia.

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[1] *Histoire et Mémoires de la Société Royale de Médecine*, 1780—1781; *Hist.* p. 346.

[2] Mérat and De Lens, *op. supra cit.* t. v. p. 141.

[3] It is remarkable that electricity and oxygen, two agents of vast influence in nature, should possess but slight remedial power.

[4] *Elements of Experimental Chemistry*, vol. i. p. 255, 10th edit. London, 1826.

[5] *Ibid.*

[6] *Phil. Trans.* vol. lvi. for the year 1766.

β. IN THE ORGANISED KINGDOM.—Hydrogen is an essential constituent of all organised beings (animals and vegetables), either combined with oxygen, to form water, or otherwise. Certain fungi exhale hydrogen gas both night and day.[1]

PREPARATION.—Hydrogen is usually procured by the action of zinc on diluted sulphuric acid.

Add some granulated zinc to a mixture of 1 part of oil of vitriol and 6 or 8 parts of water by measure. The operation may be effected in a common glass retort; or in a glass or stone bottle, fitted with a bung having two perforations,—one to admit a flannel tube, which descends to the bottom of the bottle, the other for the exit tube. A very convenient vessel, and one not liable to breakage, is made of tinned copper. It should be furnished with two apertures closed with corks, one of which is perforated to receive a flexible metallic exit tube. One equivalent of zinc decomposes one equivalent of water, and unites with one equivalent of oxygen, forming one equivalent of the oxide of zinc, while an equivalent of hydrogen is evolved from the water. This equivalent of oxide of zinc combines with an equivalent of sulphuric acid, and forms one equivalent of the sulphate of zinc. $Zn+HO+SO^3=ZnO, SO^3+H$.

MATERIALS.		COMPOSITION.			PRODUCTS.	
1 eq. Water ..	9	*1 eq. Hydrogen*	1		1 eq. Hydrogen	1
		1 eq. Oxygen ..	8	*1 eq. Oxide Zinc* 40·5		
1 eq. Zinc			32·5			
1 eq. Sulphuric Acid			40		1 eq. Sulphate Zinc	80·5
			81·5			81·5

It is remarkable that zinc alone does not decompose water, but sulphuric acid enables it to do so.

As 32·5 parts, by weight, of pure zinc evolve 1 part, by weight, of pure hydrogen, one troy ounce, or 480 grains, should disengage 14·769 grains, or about 690 cubic inches of gas. (One ounce of zinc is found to cause the evolution of 615 cubic inches of hydrogen gas—*Graham.*)

PROPERTIES.—Hydrogen is a colourless, tasteless, and, when pure, odourless gas. That obtained by the above process is not quite pure. It usually contains traces of sulphuretted hydrogen and carbonic acid, which may be removed by washing the gas with either lime water or a solution of caustic alkali, and it also has a peculiar odour. When prepared with sulphuric acid, contaminated with arsenious acid, it contains traces of arsenuretted hydrogen. Its sp. gr. is 0·0693 (0·06926—*Graham;* between 0·0691 and 0·0695—*Dumas* and *Boussingault*), so that it is about 14·4 times lighter than atmospheric air. Its refractive power is very high. It is combustible, burning in atmospheric air or oxygen gas with a pale flame, and forming water. It is not a supporter of combustion. It is a constituent of some powerful acids, as the hydrochloric, and of a strong base, ammonia. In its chemical relations it is analogous to the metals.

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[1] De Candolle, *Phys. Vég.* tom. i. p. 459.

Characteristics.—Free hydrogen is recognised by its combustibility, the pale colour of its flame, its not supporting combustion, and by its yielding, when exploded with half its volume of oxygen, water only.

The existence of hydrogen in organic substances is ascertained by the production of water when they are burnt in a combustion tube: the hydrogen constitutes one-ninth part, by weight, of the water produced.

PHYSIOLOGICAL EFFECTS. α. *On Vegetables.*—Plants which are deprived of green or foliaceous parts, or which possess them in small quantity only, cannot vegetate in hydrogen gas: thus seeds will not germinate in this gas; but vegetables which are abundantly provided with these parts vegetate for an indefinite time in hydrogen.[1] Applied to the roots of plants in the form of gas, it is injurious,[2] but an aqueous solution of it seems to be inert.[3] It has been said that when plants are made to vegetate in the dark, their etiolation is much diminished if hydrogen gas be mixed with the air around them; and in proof of this, Humboldt mentions several plants which retained their green colour though growing in the dark in the Freyberg mines,[4] where the surrounding air contained hydrogen.

β. *On Animals generally.*—Injected into the jugular vein of a dog, hydrogen produces immediate death, probably from its mechanical effects in obstructing the circulation and respiration.[5]

γ. *On Man.*—It may be breathed several times without any injurious effects. Scheele made twenty inspirations without inconvenience. Pilatre de Rozier frequently repeated the same experiment; and to shew that his lungs contained very little atmospheric air, he applied his mouth to a tube, blew out the gas, and fired it, so that he appeared to breathe flame. If much atmospheric air had been present, detonation must have taken place in his lungs.[6] If we speak while the chest is filled with hydrogen, a remarkable alteration is perceived in the tone of the voice, which becomes softer, shriller, and even squeaking. That this effect is, in part at least, if not wholly, physical, is shewn by the fact that wind instruments (as the flute, pitchpipe, and organ) have their tones altered when played with this gas. The conclusion which has been drawn by several experimenters as to the effects of breathing hydrogen, is, that this gas possesses no positively injurious properties, but acts merely by excluding oxygen.

USES.—α. In *pulmonary consumption*, Dr. Beddoes recommended inhalations of a mixture of atmospheric air and hydrogen gas, on the ground that in this disease the system was hyperoxygenised. The inhalation was continued for about fifteen minutes, and repeated several times in the day.[7] Ingenhousz fancied that it had a soothing effect when applied to wounds and ulcers.

β. In *rheumatism* and *paralysis* it has been used by Reuss as a resolvent.

γ. A *flame of hydrogen* has been employed in Italy as a cautery, to stop caries of the teeth.[8]

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[1] Saussure, *Recherches Chém. sur la Végét.* pp. 195 and 209.
[2] *Ibid.* p. 105.
[3] De Candolle, *Physiol. Végét.* t. iii. p. 1360.
[4] Thomson's *Syst. of Chemistry*, vol. iv. p. 347-8, 6th edit.
[5] Nysten, *Recherches*, p. 10.
[6] Beddoes, *New Method of treating Pulmonary Consumption*, p. 44.
[7] *Op. supra cit.*
[8] *Dict. Mat. Méd.* par Mérat et De Lens.

AQUA HYDROGENII. *Hydrogen Water.*—This is an aqueous solution of hydrogen prepared by artificial pressure. At the ordinary pressure and temperature of the atmosphere, water dissolves about 1½ per cent. of its bulk (1·61 per cent. *Dr. W Henry;* 2 per cent. *Dalton;* 4·6 per cent. *Saussure*). The *eau hydrogénée,* formerly prepared at the Tivoli, by strong pressure, contained a third of its volume, or about 33 per cent. of its bulk of hydrogen;[1] and Gmelin[2] states, on the authority of De Marty, that the water gradually acquired the power of taking up more hydrogen (in two years not quite an equal volume), and he suggests that perhaps a *suboxide of hydrogen,* H^2O, was formed. Hydrogen water is said to have been successfully employed in the treatment of diabetes.[3]

3. AQUA.—WATER, or the Protoxide of Hydrogen.

Symbol Aq. *Formula* HO. *Equivalent Weight* 9. *Equivalent Volume of Steam* 1 or □

HISTORY.—The ancients regarded water as an elementary substance, and as a constituent of most other bodies. This opinion, apparently supported by numerous facts, was held until the year 1783.

The discovery[4] of the composition of water has been at different times claimed for Watt, for Cavendish, and for Lavoisier. To Watt is certainly due the credit of having made the earliest written statement of the real composition of water on record.

On the 26th of April, 1783, Watt[5] wrote a letter to Dr. Priestley in which he concludes "that water is composed of dephlogisticated air and phlogiston deprived of part of their latent or elementary heat."

The Hon. Mr. Cavendish,[6] in his paper read to the Royal Society on the 25th of January, 1784, stated that when 423 measures of inflammable air and 1000 of common air are mixed and exploded, "almost all the inflammable air, and about one-fifth of the common air, lose their elasticity, and are condensed into the dew which lines the glass."

In the summer of 1783, Dr. (afterwards Sir Charles) Blagden[7] gave some account of Cavendish's experiments, and of his conclusions therefrom, to Lavoisier,[8] who, in June 1783, repeated and verified them.

NATURAL HISTORY.—Water is found in both kingdoms of nature.

a. IN THE INORGANISED KINGDOM.—Water exists in the atmosphere; it forms seas, lakes, and rivers; it is mechanically disseminated among rocks; and, lastly, it constitutes an essential part of some minerals.—In the atmosphere it is found in two states; as a vapour (which makes about one-seventieth by volume, or one one-hundredth by weight, of the atmosphere) it is supposed to be the cause of the blue colour of the sky; and in a vesicular form, (?) it constitutes the clouds. The average depth of the ocean is calculated at between two or three miles. Now as the height of dry land above the surface of the sea is less than two miles, it is evident that if the present dry land were distributed over the bottom of the ocean, the surface of the globe would present a mass of waters a mile in depth. Even on the supposition that the mean depth of the sea is not greater than the fourth part of a mile, the solid contents of the ocean would be 32,058,939¼ cubic miles.[1] The quantity of water disseminated through rocks must be, in the aggregate, very considerable, although it is impossible to form any correct estimate of it. Water enters into the composition of many minerals, either as *water of crystallization*, or combined as a *hydrate*.

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[1] *Dict. Mat. Méd.* par Mérat et De Lens, art. *Hydrogène.*

[2] *Handbuch der Chemie,* Bd. i. S. 533, Heidelberg, 1843.

[3] Hallé, *Cours de* 1801, quoted in the *Dict. Mat. Méd.*

[4] For full details respecting the discovery of the composition of water see *Correspondence of the late James Watt on his Discovery of the Theory of the Composition of Water, with a Letter from his Son.* Edited, with introductory remarks and an appendix, by J. P. Muirhead, Esq. F.R.S.E. London, 1846.

[5] *Phil. Trans.* vol. lxxiv. for the year 1784, pp. 330 and 333.

[6] *Phil. Trans.* vol. lxxiv. for the year 1784.

[7] Crell's *Chemische Annalen* for 1786.

[8] *Mémoires de l'Académie Royale des Sciences pour l'année* 1781, p. 472. Paris, 1784. [Lavoisier's paper, though published in the Mémoires said to be for 1781, was read to the Académie on the 11th of November, 1783, and was not printed till the year 1784.]

β. IN THE ORGANISED KINGDOM.—Water is an essential constituent of vegetables and animals.

PURIFICATION.—Various methods are resorted to for the purpose of purifying common water: those which require to be noticed are *subsidence*, *filtration*, *ebullition*, *distillation*, and the addition of certain *chemical agents*.

1. *Subsidence*.—By allowing water to remain for some time in perfect repose, various impurities mechanically suspended in it gradually subside; and from these the water is decanted. In this way accumulations of filth are formed in the tanks and cisterns employed for the reception of common river water. This method of purification is sometimes the only one resorted to, and at other times is preliminary to further purifications by the following processes.

2. *Filtration*.—By this process water is rendered clear and transparent. It removes living beings and other suspended impurities, and is also capable of removing certain substances held in solution.[2] The materials employed for the filtration of water are perforated plates of metal or stoneware, unsized or bibulous paper, flannel, cloth, or other tissues, sponge, porous stone (filtering stone), charcoal (animal charcoal is more effective than vegetable charcoal), and beds of sand.

Paper is only fitted for operations on the small scale. Two kinds of filter paper are usually kept,—a coarser and a finer kind; the former for the separation of the grosser particles, the latter for the removal of finely divided matters. In chemical operations it is necessary to exercise great care in the selection of filter paper, in order to avoid the use of those papers, which communicate iron, lime, or organic matters to the liquid. The coarse or rough brownish or blueish woollen paper used by pharmaceutists is useful for the rapid filtration of water and the separation of impurities, but is unfit for collecting precipitates on.[1]

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[1] Thomson's *System of Chemistry*, 6th edit. vol. iii. p. 195.

[2] By filtration through animal charcoal, water may be deprived of colouring and odorous matters which it held in solution; and by filtration through sand, both Berzelius and Matteucci (*Lectures on the Physical Phenomena of Living Beings*, p. 31, Lond. 1847) state that a saline solution may be more or less completely deprived of salt. Matteucci found that the density of a saline solution was reduced from 1·00 to 0·91 by filtration through a tube of about 26 feet long filled with sand; but after some time the sand ceased to deprive the solution of its salt.—"It has been supposed by some that sea water, when passing up through a considerable stratum of sand, may be deprived of its salt as well as the impurities which visibly foul it. It is certain that in many places remarkably good fresh water is found by digging a few feet in the sand on the sea shore, at a very short distance from the high-water mark. This is the case at Yarmouth, on the Norfolk coast; and the water procured from these wells is purer than any other that is found about the town: but there is no direct evidence that this is sea water filtered by ascent through the sand, since it may well be supposed to be fresh water, rising from a great distance within land, that has undergone the last degree of purification by its passage through the fine clear sand of which the soil is composed for a considerable distance off the sea shore." (Saunders' *Treatise on Mineral Waters*, p. 89, 1800.)

In the stoneware filtering machines usually sold in the shops a combination of filtering materials (viz. sponge, sand, and charcoal) is generally employed.[2]

Beds of sand are used for the filtration of water on the large scale. The water-filters used in the public works of Lancashire are usually constructed as follows:—"An excavation of about six feet in depth, and of sufficient extent, is lined to a considerable thickness with well-puddled clay, to make it water-tight. Upon the clay floor is laid—first, a stratum of large stones, then a stratum of smaller stones, and finally a bed of coarse sand or gravel. To allow the air to escape from the lower beds, small upright tubes, open at both ends, are inserted in these beds, and rising above the surface of the water. The filtered water enters from the lowest bed, into a large open iron cylinder, the lower part of which is perforated for the purpose."[3]

3. *Ebullition* destroys the vitality of either animals or vegetables, expels air or carbonic acid, and causes the precipitation of carbonate of lime.

4. *Distillation.*—When properly conducted this is the most effectual method of purifying water. But distilled water is in general contaminated by traces of organic matter. (See *Aqua destillata*).

5. *The addition of chemical agents* to water is another mode which has been proposed and practised for freeing water from some of its impurities.

α. *Alum* is popularly used to clear muddy water. Two or three grains are sufficient for a quart of water. The alum decomposes the bicarbonate of lime: sulphate of lime is formed in solution, and a hydrate of alumina is precipitated in a flocculent form, carrying with it various mechanical impurities. It is obvious that alum adds nothing to the chemical purity of the water, but, by converting the carbonate into sulphate of lime, augments its hardness.

β. *Caustic alkalies* added to water holding in solution bicarbonate of lime, saturate the excess of carbonic acid, and throw down carbonate of lime, leaving an alkaline carbonate in solution.

γ. *Alkaline carbonates* soften water, decompose all the earthy salts (calcareous and magnesian sulphates, chlorides, and bicarbonates), and precipitate the earthy matters. They leave, however, in solution an alkaline salt, but which does not communicate to water the property of hardness.

δ. *Lime.*—A patent has recently been taken out by Professor Clark,[4] of Aberdeen, for the purification of waters. The patent process consists in the addition of lime to water. The lime decomposes the supercarbonate of lime held in solution, saturates the excess of carbonic acid, and forms carbonate of lime, which is precipitated. The effect of this process is similar to that of ebullition. It has no effect on the earthy sulphates and chlorides.

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[1] For an account of the relative fitness of different kinds of paper for use as filter papers, see Griffin's *Chemical Recreations*, 8th ed. p. 75, Lond. 1838.

[2] In Webster's *Encyclopædia of Domestic Economy*, pp. 530-3, will be found descriptions and figures of various filter machines.

[3] Graham's *Elements of Chemistry*, 2d ed. p. 317.

[4] See *Repertory of Patent Inventions* for October 1841; also, *A new Process for Purifying the Waters supplied to the Metropolis by the existing Water Companies; rendering each water much softer, preventing a fur on boiling, separating vegetating and colouring matter, destroying numerous water-insects, and withdrawing from solution large quantities of solid matter not separable by mere filtration.* By Thos. Clark, Professor of Chemistry in the University of Aberdeen, 2d edit. Lond. 1841.

ε. In India the seeds of *Strychnos potatorum*, called *clearing nuts*, are used for clearing muddy water. They are sold for this purpose in the ripe and dried state in the bazaars. "The natives never drink clear well water if they can get pond or river water, which is always more or less impure, according to circumstances. One of the seeds is well rubbed for a minute or two round the inside of the vessel containing the water, generally an unglazed earthen one, which is then left to settle; in a very short time the impurities fall to the bottom, leaving the water clear, and, so far as I have been able to learn, perfectly wholesome. These seeds are constantly carried about by the more provident part of our officers and soldiers in time of war, to enable them to purify their water. They are easier to be obtained than alum."[1] The nature of the action of these seeds on the water has not been ascertained: Dr. O'Shaughnessy[2] suggests that it depends on astringency.

PROPERTIES.—Pure water has the following properties:—at ordinary temperatures it is a transparent liquid, usually described as being both odourless and colourless; but it is well known that the camel can scent water at a considerable distance, so that to this animal it is odorous; and as regards its colour, we know that all large masses of water have a blueish-green colour,[3] though this is usually ascribed to the presence of foreign matters. When submitted to a compressing force equal to 30,000 lbs. on the square inch, 14 volumes of this liquid are condensed into 13 volumes, so that it is elastic. A cubic inch of water, at 62° F., Bar. 30 inches, weighs 252·458 grains, so that this fluid is about 815 times heavier than atmospheric air; but being the standard to which the gravities of solids and liquids are referred, its specific weight is usually said to be 1·. An imperial pint weighs, at 62°, 8,750 grs. (= 20 oz. Avoirdupois; or 1 lb. 6 oz. 1 drachm 2½ scruples Apothecaries' weight). Water has the greatest density at 39°·2 Fahr. At a temperature of 32° it crystallizes, and in so doing expands. The sp. gr. of ice is 0·916. The fundamental form of crystallized water (ice) is the rhombohedron. Water evaporates at all temperatures, but when the barometer stands at 30 inches, water boils at 212°, and is converted into steam, whose bulk is about 1700 times that of water, and whose sp. gr. is 0·622 (that of hydrogen being 1).

In its chemical relations water may be regarded as a neutral body. It reacts neither as an acid nor as an alkaline or basic body. It combines with acids, alkalies, and many salts. When deprived of water, the oxygen acids no longer present the qualities which characterise acids. Thus anhydrous sulphuric acid does not redden litmus, and exhibits a disposition to unite with salts rather than with bases. Water rapidly absorbs some gases, as fluoride of boron, ammonia, &c. It is neither combustible nor a supporter of combustion.

Characteristics.—Water is recognised by being volatile, incombustible, incapable of supporting combustion, miscible with alcohol in all proportions, with ether in certain proportions, and not miscible with the fixed oils. When pure it is odourless, tasteless, and possesses neither acid nor alkaline qualities.

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[1] Roxburgh's *Flora Indica*, vol. i. p. 576, Serampore, 1832.

[2] *The Bengal Dispensatory*, Lond. 1842.

[3] For some remarks on the colour of the ocean, see Jameson's *Journal*, vol. xxv.

It is greedily absorbed by fused chloride of calcium, which has great affinity for it, and is, therefore, employed for drying gases and absorbing moisture. Potassium thrown on it in the open air takes fire. By the galvanic battery it is decomposed into two measures of hydrogen and one of oxygen gas.

Anhydrous sulphuric acid and fluoride of boron produce dense white fumes in an atmosphere containing aqueous vapour. Hydrochloric acid and some other gases also produce white fumes when brought in contact with aqueous vapour.

The quantity of water contained in solid bodies is frequently determined by drying them and ascertaining the loss which they in consequence suffer. Desiccation may be effected by heat, either alone or aided by a current of artificially dried air; or by a vacuum, either alone or aided by the presence of oil of vitriol (*Leslie's method of drying*). In some cases these methods fail to expel the whole of the water, which can only be got rid of by the substitution of another substance for it.

In organic analysis, the quantity of water produced is determined by passing the volatile products of combustion over chloride of calcium contained in a tube ascertaining the increase of weight which this salt thereby gains.

COMPOSITION.—The composition of water is determined both by analysis and synthesis. If this liquid be submitted to the influence of a galvanic battery, it is decomposed into two gases; namely, one volume of oxygen and two volumes of hydrogen. These gases, in the proportions just mentioned, may be made to re-combine, and form water, by heat, electricity, or spongy platinum.

1 eq. Hydrog. = 1.	1 eq. Oxyg.=8.	=	1 eq. Steam =9.

	Atoms.	Eq. Wt.	Per Cent.	Berz. & Dulong.
Hydrogen	1	1	11·11	11·1
Oxygen	1	8	88·88	88·9
Water	[illegible]	9	100·00	100·0

	Vol.	Sp. Gr.
Hydrogen gas	1	0·0692
Oxygen gas	0·5	0·5528
Aqueous vapour	1	0·6220

TESTS OF THE PURITY OF WATER.—See *Aqua destillata.*

PHYSIOLOGICAL EFFECTS.—Water is an essential part of the blood and of all living tissues. It is from this liquid that the tissues derive their properties of extensibility and flexibility. It gives fluidity to the blood, and enables the transportation of organic particles from one part of the body to another to be effected. Lastly, it contributes to most of the transformations which occur within the body.

Considered dietetically, aqueous drinks serve several important purposes in the animal economy: they repair the loss of the watery part of the blood, caused by evaporation and the action of the secreting and exhaling organs, and they act as solvents of various alimentary substances, and thereby assist the stomach in the act of digestion. If, however, they are swallowed in excessive quantity, they may impede digestion by diluting the gastric juice. It is not improbable that water acts as a real nutritive agent—that is, assists in the formation of the solid parts of the body.

As an agent for the communication or abstraction of heat to or from the body, water has been before noticed (see *ante*, p. 17 et seq.) Furthermore, the influence of atmospheric humidity in modifying the character of climates has likewise been briefly referred to (see *ante*, p. 69).

Water moderately warm, and which neither cools nor heats the body, acts locally as an emollient, softening and relaxing the various tissues to which it is applied (see *Emollients*, p. 166). When swallowed it allays thirst, becomes absorbed, mixes with, and thereby attenuates, the blood (see *Diluents*, p. 168), and promotes exhalation and secretion, especially of the watery fluids. Administered in large quantities it excites vomiting. The continued excessive use of water has an enfeebling effect on the system, both by the relaxing influence on the alimentary canal and by the excessive secretion which it gives rise to.

Injected into the veins in moderate quantities, tepid water has no injurious effects; it quickens the pulse and respiration, and increases secretion and exhalation. Large quantities check absorption (see *ante*, p. 103), and cause difficulty of breathing, and an apoplectic condition.. Thrown with force into the carotid artery, it kills by its mechanical effect on the brain.

USES.—Besides the dietetical and thermotic purposes for which water is employed in medicine, it serves as a diluent, humectant, emollient, evacuant, and, in pharmacy, as a solvent.

Water or bland aqueous liquids are employed in some cases of poisoning. They serve to dilute the acrid and irritant poisons, the intensity of whose action on the stomach they lower. Moreover, the presence of aqueous fluids favours the expulsion of substances by vomiting (see *Antidotes*, pp. 154 and 159).

In preternatural dryness and rigidity of parts (*e. g.* of mucous surfaces, the skin, wounds, and ulcers), water and mild aqueous fluids are useful moisteners and emollients.

The copious use of water augments the quantity of fluid thrown out of the system by the cutaneous and pulmonic surfaces, and by the kidneys (see *ante*, pp. 236, 245, and 250). If our object be to promote diaphoresis, external warmth should be conjoined with the internal use of diluents; whereas, when we wish to excite the renal vessels, the skin should be kept cool. In inflammatory affections of the urinary passages, we advise the free employment of aqueous fluids, with the view of diluting the urine, and thereby of rendering it less acrid and irritating.

The subject of *hydropathy* has been already briefly alluded to (see *ante*, p. 33).

What is called *water-dressing* may be regarded as a modified and improved form of poultice. It consists in the application of two or three layers of soft lint dipped in water and applied to inflamed parts, wounds, and ulcers, the whole being covered with oiled silk or Indian rubber, which should project beyond the margin of the lint, to retain the moisture and prevent evaporation. Dr. Macartney[1] considers it to operate differently to a poultice: unlike the latter, he says, it prevents or diminishes the secretion of pus, checks the formation of exuberant granulations, and removes all pain. Moreover, the water is not apt to become sour, like a poultice, and does not injure the sound part.[2]

Water is frequently employed in pharmacy for extracting the active principles of various medicinal agents. The solutions thus procured are termed by the French reformers[1] of pharmaceutical nomenclature *hydroliques*, or *hydrolica* (from ὕδωρ, *water*). Those prepared by solution or mixture are termed *hydrolés*, and are divided by Cottereau[2] into three classes;—mineral (as lime-water), vegetable (as almond emulsions, mucilage, infusions, decoctions, &c.), and animal (as broths). Those obtained by distillation are denominated *hydrolats*.

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[1] *Treatise on Inflammation*, p. 180, London, 1838.

[2] For further details respecting the water-dressing, see, besides the work already quoted, *Mém. de l'Académie Royale de Médecine*, Fasc. 1, 1836.—*Lancet*, vol. ii. for 1834-5, pp. 121, 277, and 484; and vol. i. for 1835-6, p. 450.

1. **AQUA DESTILLATA**; *Aqua Distillata; Distilled Water.*—Obtained by distilling common water in a proper still. The first twentieth (fortieth, *Ph. L.*) part should be rejected: the last portions ought not to be distilled. The first distilled portion is to be rejected, as it may contain carbonic acid, ammonia, and other volatile impurities. The latter portions are not to be distilled, to guard against empyreuma, from the charring of organic matters. The still in which the operation is conducted ought not to be employed for any other purpose, otherwise the water is apt to receive a faint smell, and taste of the last matters subjected to distillation. "A copper still should be used provided with a copper or block tin worm, which is not used for the distillation of spirits, as traces of alcohol remaining in the worm and becoming acetic acid cause the formation of acetate of copper, which would be washed out and contaminate the distilled water. The use of white lead cement about the joinings of the worm is also to be avoided, as the oxide of lead is readily dissolved by distilled water" (Graham). Distilled water remains unchanged on the addition of any of the following tests:—Solutions of the caustic alkalies, lime, oxalic acid, the barytic salts, acetate of lead, nitrate of silver, and soap. If turbidness, milkiness, or precipitate, be occasioned by any of these, we may infer the existence of some impurity in the water. But water which has been repeatedly distilled gives traces of acid and alkali when examined by the agency of voltaic electricity, which, therefore, is the most delicate test of the purity of water. Distilled water also usually contains traces of organic matter. Nitrate of silver is the most sensible test of its presence:[3] a solution of this salt in pure water, preserved in a well-stoppered bottle, undergoes no change of colour by exposure to light; but if any vegetable or animal matter be present, the metal is partially reduced, and the liquid acquires a dark or reddish tint.

Owing to its freedom from air and carbonic acid, distilled water is flat, mawkish, and by no means agreeable to the taste. Its dietetical employment as a substitute for common water was suggested by Dr. Heberden[4] and warmly advocated and practised by Dr. Lambe[5] on theoretical rather than practical grounds. Its use has also been recommended in some forms of lithiasis (especially in the oxalate of lime diathesis). At the present time, however, distilled water is almost exclusively employed for chemical and pharmaceutical purposes.

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[1] *Pharmaceutical Nomenclature* of MM. Chereau and Henry, in Duncan's *Supplement to the Edinburgh New Dispensatory*, p. 152.

[2] *Traité Elémentaire de Pharmacologie*, Paris, 1835.

[3] Dr. Davy, in Jameson's *Edinburgh New Philosophical Journal*, Dec. 1828, p. 129.

[4] *Remarks on the Pump Water of London*, in the *Medical Transactions published by the College of Physicians in London*, vol. i.

[5] *Reports of the Effects of a peculiar Regimen on Scirrhous Tumours and Cancerous Ulcers*, 1809; *Additional Reports on the Effects of a peculiar Regimen*, 1815.

2. **AQUÆ MEDICATÆ**; *Medicated Waters; Aquæ Destillatæ; Aquæ Distillatæ; Distilled Waters; Hydrolata*, or *Hydrolats.*—Obtained by submitting either fresh, salted, or dried vegetables, or their essential oils, to distillation with water; or by diffusing the essential oils through water. The vegetables employed in the preparation of the distilled water are either immersed in the water or merely exposed to the action of steam.

The medicated waters prepared by distillation from recent vegetables have a finer flavour than those obtained by the diffusion of the oil; but the latter are purer and more permanent. Rose and elder waters are prepared either from the fresh or pickled (salted) flowers. In the preparation of these waters, whether from the vegetables or from the volatile oils, it has been usual to add, either before or after distillation, a portion of spirit of wine, to preserve them from becoming mucilaginous and sour. But according to Mr. Warington's experiments,[1] the practice is injurious, since the spirit becomes gradually converted into acetic acid, and thus renders the waters distinctly acid.

The usual method of preparing these waters is by diffusing the oils through water by the aid of sugar or magnesia; and in the London Pharmacopœia for 1836 they were ordered to be extemporaneously prepared

> "by carefully triturating a drachm of any distilled oil with a drachm of carbonate of magnesia, and afterwards with four pints of distilled water. Lastly, let the water be strained."—*Ph. Lond.*

The magnesia effects the minute division, and thereby promotes the solution, of the oil in the water. A minute portion of the magnesia dissolves in the water. Moreover, when the oils possess acid properties (as the old oils of pimento, cloves, and cinnamon), the magnesia saturates the acids. Prepared in this way the medicated waters usually contain a minute portion of magnesia in solution, and, by exposure to the air, let fall flocculi of the carbonate. But the magnesia unfits them for the preparation of solutions of some of the metallic salts (*e. g.* bichloride of mercury and nitrate of silver).

The mucilaginous flocculi which form in the distilled waters are microscopic algaceous plants.[2]

3. **INFUSA**; *Infusions.*—These are aqueous solutions of vegetable substances obtained without the aid of ebullition. They are usually prepared by digesting soft water (cold or hot, according to circumstances) on the substance sliced, bruised, or reduced to coarse powder, in a glazed earthenware or porcelain vessel fitted with a cover. Polished metallic vessels retain the heat better, but are objectionable on account of their ready corrosion. Hard water is a less perfect solvent of organic matter than soft water, and, moreover, it becomes turbid (from the deposition of chalk) by keeping: hence it should not be employed in the preparation of infusions. Cold water is used when the active principle is very volatile, or when it is desirable to avoid the solution of any substance soluble in hot water. Thus when the object is to extract the bitter principle from calumba or Iceland moss without taking up the starchy matter, cold water is preferred. In general, however, boiling water is used. Infusions are preferred to decoctions when the active principle is

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[1] *Pharmaceutical Journal*, vol. iv. p. 558.

[2] See a paper by the author, in the *Pharmaceutical Journal*, vol. vii. p. 337.

either volatilisable by a boiling heat, as in the case of essential oil, or readily undergoes some chemical change by ebullition, as in the case of senna.

Infusions may also be prepared by percolation or displacement. The advantage of this process (which will be more fully noticed hereafter under the head of *Tincturæ*) is that substances, especially starch and some allied principles, which do not add to the medicinal efficacy of the preparation though they render it more apt to decompose or become mouldy, are not taken up. Infusions prepared by percolation being thus less liable to decay, may be made in larger quantity, and are therefore more economical and convenient.

To preserve vegetable infusions Mr. Alsop[1] recommends that they should be poured while hot into bottles which are to be made perfectly full and to be closed with accurately ground stoppers or with perforated corks, closing immediately the aperture from which the displaced fluid escapes by sealing wax. Dr. Christison[2] suggests that the infusions prepared by percolation would keep better if they were heated to 212° in well-corked bottles by immersing them in boiling water and afterwards separating the coagulated albumen by filtration.

4. **DECOCTA**; *Decoctions.*—These are prepared by boiling organic substances in water. They should be strained while hot; since, in some cases (*e. g.* that of cinchona), the liquid becomes turbid on cooling.

DECOCTO-INFUSA. *Decocto-infusions.*—These are decoctions to which, after they have ceased to boil, but while they are still hot, other substances are added, and allowed to digest therein.[3]

By ebullition in water the volatile constituents of vegetables are dissipated; and hence, when these are the active principles, the process is an objectionable one. It is obvious that the saffron in *decoctum aloës compositum*, the sassafras in the *decoctum sarzæ compositum*, and the juniper fruit in the *decoctum scoparii compositum*, are deprived of their volatile oils by boiling, and, therefore, these preparations are on that account objectionable.

DIVISION OF NATURAL WATERS.

Natural waters may be divided into *terrestrial* and *atmospheric:* the former division includes spring, well, river, lake, marsh, mineral, and sea waters; the latter comprehends rain and dew, ice and snow. But for our present purpose they may most conveniently be arranged in three classes;[4] viz. *common waters*, *sea water*, and *mineral waters*.

1. *Aquæ Communes.*—*Common Waters.*

Under this head are comprehended those waters which are used for drink, for dressing food, or for other purposes of domestic economy. It includes the waters commonly known as *rain*, *spring*, *river*, *well* or *pump*, *lake*, and *marsh waters*.

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[1] *Pharmaceutical Journal*, vol. i. p. 57.

[2] *Dispensatory*, 2d edit. p. xiv.

[3] *Pharmaceutical Journal*, vol. vii. p. 353.

[4] See Dr. Thomson's *System of Chemistry*, vol. iii. p. 191, 6th edit. Lond. 1820.

Before proceeding to notice these several varieties of waters it will be useful to consider the comparative properties of the pure natural waters, of hard waters, and of natural waters impregnated with organic matters.

Pure natural waters.—Besides rain water, some spring, well, and river waters are remarkable for their purity. The water of the Malvern springs is remarkable for its extreme purity. According to Sir Charles Scudamore's analysis,[1] this water contains only about a third part of the solid matter found by Mr. R. Phillips in Thames water taken at Chelsea. These waters are beneficial in lithiasis, chiefly on account of their purity. The well water of Ascot Heath is also remarkably pure. According to Mr. Squire,[2] it contains only one-fifth of the lime found in Thames water. In Scotland, springs containing only between an 8,000th and 12,000th of saline constituents are common.[3]

Though the purest waters are the most wholesome, yet very pure water is possessed of one very dangerous quality, viz. that of rapidly corroding lead, and thereby acquiring an impregnation of this metal. Distilled water has no action on lead, provided the air be excluded; but when this is admitted, a thin white crust[4] of carbonate and hydrate of the oxide of lead is speedily formed. Now it is very remarkable that the neutral salts usually found in spring water impair the corrosive action of water and air, and thus exercise a protecting influence. To the presence of saline matter, therefore, is to be ascribed the comparative infrequency of the plumbeous impregnation of water kept in leaden cisterns or transmitted through leaden pipes. All salts do not possess an equally protective influence, the carbonates and sulphates being most, the chlorides (muriates) the least, energetic of those saline substances commonly met with in spring waters. Rain and other pure kinds of water which contain but minute portions of these protecting salts readily acquire an impregnation of lead from roofs, gutters, cisterns, or pipes, made of this metal.[5] "There is another way in which lead is occasionally acted upon by water, and to which attention was first directed by Dr. Paris: it is in consequence of galvanic action, and in cases where iron and lead are in metallic contact, as often happens in the employment of iron bars to strengthen and support leaden cisterns, and in the introduction of iron pumps under similar circumstances: in these cases, though the lead is rendered electro-negative, and so far protected from acid reaction, it becomes more susceptible of, and exposed to, the agency of electro-positive elements, among which are alkalies and alkaline earths, and these exert considerable solvent power over it. So that all such combinations of lead and iron, zinc, &c. should be cautiously avoided. Lastly, there is another source of contamination of water by lead, which is this;—leaden cisterns have often leaden covers, and the water, spontaneously evaporating from the cistern, is condensed (now in the form of *pure* or *distilled* water) upon the lid, upon which it exerts its usual energetic action, and drops back into the body of the cistern, contaminated by lead: so that wood not leaded should be used in all cases for covering leaden reservoirs."[1]

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[1] *Chemical and Medical Report of the Properties of the Mineral Water of Buxton, &c. &c.* 1820.

[2] *Pharmaceutical Journal*, vol. iv. p. 9.

[3] *Christison's Dispensatory*, 2d edit.

[4] Dr. Christison (*Transactions of the Royal Society of Edinburgh*, vol. xv. part ii. 1842), made three analyses of this crust, and found that it consisted of oxide of lead, carbonic acid, and water, in proportions which nearly correspond to the formula $3\,\text{Pb O} + 2\,\text{CO}^2 + \text{Aq.}$; that is, a compound of three equivalents of oxide of lead, two of carbonic acid, and one of water; or rather, a compound of two equivalents of carbonate of lead in union with one equivalent of hydrated oxide of lead = $2\,(\text{Pb O} + \text{CO}^2) + (\text{Pb O} + \text{Aq.})$

[5] I have been informed that the presence of mortar in a cistern promoted the corrosion of the lead by the water.

Water impregnated with lead in the way above alluded to possesses the following properties:—By exposure to the air it becomes covered with a thin white film, and the vessel in which it is contained becomes lined with a thin white incrustation of a pearly lustre. This crust dissolved in acetic acid yields a solution which is rendered blackish-brown by sulphuretted hydrogen, and yellow by either iodide of potassium or bichromate of potash.

The continued use of water containing lead gives rise to *lead* or *painter's colic* (see *ante*, p. 187). If the cause of the malady be not discovered, and the water not discontinued, *palsy* usually succeeds colic (see *ante*, p. 188).

The following conclusions, drawn by Dr. Christison,[2] as to the employment of lead pipes for conducting water, are of considerable importance, and therefore deserve especial attention.

"1. Lead pipes ought not to be used for the purpose, at least where the distance is considerable, without a careful examination of the water to be transmitted.

"2. The risk of a dangerous impregnation with lead is greatest in the instance of the purest waters.

"3. Water which tarnishes polished lead when left at rest upon it in a glass vessel for a few hours, cannot be safely transmitted through lead-pipes without certain precautions.[3]

"4. Water which contains less than about an 8000th of salts in solution cannot be safely conducted in lead-pipes without certain precautions.

"5. Even this proportion will prove insufficient to prevent corrosion, unless a considerable part of the saline matter consist of carbonates and sulphates, especially the former.

"6. So large a proportion as a 4000th, probably even a considerably larger proportion, will be insufficient, if the salts in solution be in a great measure muriates.

"7. It is, I conceive, right to add, that in all cases, even though the composition of the water seems to bring it within the conditions of safety now stated, an attentive examination should be made of the water after it has been running for a few days through the pipes. For it is not improbable that other circumstances, besides those hitherto ascertained, may regulate the preventive influence of the neutral salts."

Hard water.—Common water which decomposes and curdles soap is denominated *hard water*, to distinguish it from those waters which are readily miscible with soap, and which are termed *soft waters.* Spring and well waters are frequently hard, while rain water and usually river water are soft. The hardness of water depends on earthy salts, the most common of which is sulphate of lime. By the mutual action of this salt and soap, double decomposition is effected: the sulphuric acid unites with the alkali of the soap, while the fatty acids unite with the lime to form an insoluble earthy soap. On this is founded the use of a *tincture of soap* as a *soap test* of the hardness of water. This tincture is made by dissolving one drachm of curd soap in an imperial pint of proof spirit.[1]

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[1] Brande's *Dictionary of Materia Medica and Practical Pharmacy*, p. 80, Lond. 1839.

[2] *Trans. of the Royal Society of Edinburgh*, vol. xv. part ii. p. 271.

[3] "Conversely, it is probable, though not yet proved, that if polished lead remain untarnished, or nearly so, for twenty-four hours in a glass of water, the water may be safely conducted through lead pipes."

According to Dr. Christison, water which contains more than $\frac{1}{2000}$th of saline matter is scarcely fit for domestic use; that which contains $\frac{1}{4000}$th or upwards is called hard; that which contains not above $\frac{1}{5000}$th part lathers with soap, may be used for washing, and is, therefore, called soft; that which does not contain more than $\frac{1}{6000}$th part may be used in pharmacy according to the Edinburgh Pharmacopœia. But this statement requires some modification; the hardness of the water depending more on the nature than on the quantity of the solid constituents. Thames water, a remarkably soft water, contains, according to Mr. R. Phillips, from $\frac{1}{3608}$th to $\frac{1}{3763}$d of solid matter in solution. The deep-well water of the London Basin yields, according to Professor Graham, $\frac{1}{1240}$th part of solid matter, though, as it contains carbonate of soda and no sulphate of lime, and but little other earthy salts, it is a soft and alkaline water.

Hard water[2] is a less perfect solvent of organic matter than soft water: hence, in the preparation of infusions and decoctions, and for many economical purposes, as for tea-making and brewing, it is inferior to soft water; and, for the same reason, it is improper as a drink in dyspeptic affections. Moreover, it proves injurious in urinary deposits. The unfavourable effects of hard waters on the animal system are especially manifested in horses. "Hard water, drawn fresh from the well," observes Mr. Youatt,[3] "will assuredly make the coat of a horse unaccustomed to it stare, and it will not unfrequently gripe and otherwise injure him. Instinct or experience has made even the horse himself conscious of this; for he will never drink hard water if he has access to soft; he will leave the most transparent and pure [?] water of the well for a river, although the water may be turbid, and even for the muddiest pool."[4]

Water containing organic matter in solution or suspension.—Decomposing organic matter in suspension or solution, is found in every river water in a greater or less proportion. Ordinarily the quantity is insufficient to act injuriously; but it cannot be doubted that water strongly contaminated with it must be deleterious. Where, however, the quantity present is insufficient to produce any immediately obvious effects, it is by no means easy to procure decisive evidence of its influence on the system. In those cases in which its operation has been unequivocally recognised, it has manifested itself by the production of dysentery.[1] Its influence in a milder form is attended with slight relaxation of bowels. "The beneficial effects derived from care as to the qualities of water," says Mr. Chadwick,[2] "is now proved in the navy, where fatal dysentery formerly prevailed to an immense extent, in consequence of the impure and putrid state of the supplies; and care is now generally exercised on the subject by the medical officers of the army."

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[1] For the mode of using this test, see the *Repertory of Patent Inventions* for October 1841; and *Pharmaceutical Journal*, vol. vi. p. 526.

[2] Sulphate of lime or gypsum is the ordinary constituent of hard waters. Dioscorides (lib. v. cap. 134) describes it as possessing an astringent property, and, when drank, destroying life; and Pliny (lib. xxxvi. cap. 59) states, that C. Proculeius killed himself by taking it. From the few observations respecting it which have been published (see Wibmer, *Die Wirkung der Arzneimittel und Gifte*, vol. ii. p. 11), it appears that it acts on the system as an astringent, causing constipation and disordered digestion. Parent du Chatelet (quoted by Mr. Chadwick) ascribes to it a purgative quality; and refers the chronic diarrhœa, so often observed in the hospital of Salpêtrière and the prison of St.-Lazarus, to the "very great proportion of sulphate of lime and other purgative salts" contained in the water with which both these establishments are supplied.

[3] *The Horse*, p. 359; Lond. 1831.

[4] "Some trainers have so much fear of hard or strange water, that they carry with them to the different courses the water that the animal has been accustomed to drink, and that they know agrees with it."

The decomposing organic matter above referred to consists principally of the exuviæ of animal and vegetable substances.[3] The water of some of the wells of the metropolis are occasionally contaminated with the odour and flavour of gas-tar. I have myself found this to be the case in a well water obtained near the London Hospital.

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[1] At the Nottingham Assizes, in July 1836, it was proved at a trial (Jackson *versus* Hall), on which I was a witness, that dysentery, in an aggravated form, was caused in cattle by the use of water contaminated with putrescent vegetable matter, produced by the refuse of a starch manufactory. The fish (perch, gudgeon, pike, roach, and dace,) and frogs in the pond, through which the brook ran, were destroyed. All the animals (cows, calves, and horses,) which drank of this water, became seriously ill; and in eight years the plaintiff lost twenty-four cows and nine calves, all of a disease (dysentery) accompanied by nearly the same symptoms. It was also shewn that the animals sometimes refused to drink the water; that the mortality was in proportion to the quantity of starch made at different times; and that, subsequently, when the putrescent matter was not allowed to pass into the brook, but was conveyed to a river at some distance, the fish and frogs began to return, and the mortality ceased among the cattle. The symptoms of illness in the cows were as follows: the animals at first got thin, had a rough staring coat, and gave less milk (from two to three quarts less every day); they then became purged, passed blood with the fæces, and at length died emaciated and exhausted. On a post-mortem examination, the intestinal canal, throughout its whole length, was found inflamed and ulcerated. The water, which I examined, was loaded with putrescent matter, and contained chloride of calcium (derived from the chloride of lime employed in bleaching the starch). Traces of free sulphuric acid were occasionally found by one witness.

"Dr. M. Barry affirms that the troops were frequently liable to dysentery while they occupied the old barracks at Cork; but he has heard that it has been of rare occurrence in the new barracks. Several years ago, when the disease raged violently in the old barracks (now the depôt for convicts), the care of the sick was, in the absence of the regimental surgeon, entrusted to the late Mr. Bell, surgeon, in Cork. At the period in question, the troops were supplied with water from the river Lee, which, in passing through the city, is rendered unfit for drinking by the influx of the contents of the sewers from the houses, and likewise is brackish from the tide, which ascends into their channels. Mr. Bell, suspecting that the water might have caused the dysentery, upon assuming the care of the sick, had a number of water carts engaged to bring water for the troops, from a spring called the Lady's Well, at the same time that they were no longer permitted to drink the water from the river. From this simple, but judicious arrangement, the dysentery very shortly disappeared among the troops." (Dr. Cheyne, *On Dysentery, in the Dublin Hospital Reports*, vol. iii. p. 11).

[2] *Report to Her Majesty's Principal Secretary of State for the Home Department, from the Poor Law Commissioners, on an Inquiry into the Sanatory Condition of the Labouring Population of Great Britain*, p. 78, 1842.

[3] "In addition to its saline or natural impurities, the well water of London is sometimes contaminated by organic matters, the source of which, especially in the pump water of churchyards, is sufficiently obvious; and such is usually the place selected for the parish pump. This disgusting source of water should be avoided; and the disgraceful system of burying the dead in the streets of the metropolis should be authoritatively discontinued. Of this nuisance abundant instances occur to every one who walks about London; the churchyard of St. Clement's, in the Strand, is a fair specimen, and there are many infinitely worse. In these the same graves are repeatedly opened, and the coffins thrust in one upon another, according to the most inexplicable system; and it is beneath this superstratum that the waters of the adjacent wells flow, in some instances, perhaps, deep enough to avoid direct contamination, but never free from the suspicion of the oozings of the vicinity." (Brande's *Dictionary of Materia Medica and Practical Pharmacy*, p. 81, 1839.) In the *Report on the Health of Towns* (*Effect of Interment of Bodies*), dated 14th June, 1842 (327), it is stated that this pump has been obliged to be shut up, as the water was found unfit for use.

The quantity of organic matter contained in common water has not been accurately determined. Dr. Lambe[1] states, that from 30 gallons of Thames water, collected at London, he procured 28 grains of a carbonaceous substance. But from Thames water taken out of the river at Windsor, the quantity was considerably less. From six gallons of water he did not procure one grain of this charcoally matter.

Thames water, when carried to sea in casks, soon becomes putrid and offensive, and evolves inflammable vapour.[2] This is owing to the presence of decomposing organic matter. If, however, the water in this fetid state be racked off into larger vessels, and exposed to the air, a slimy deposit is formed, and the water becomes clear, sweet, and palatable. The cleansing which this and other river waters undergo, by which they are deprived of organic matters, seems to depend on the oxidation of the vegetable and animal remains, partly by the oxygen of the air, partly by the deoxidation of the alkaline and earthy salts, as the sulphates.

I have already had occasion to refer to the evolution of sulphuretted hydrogen gas from waters containing both sulphates and decomposing organic matter (see *ante*, p. 69).

Living beings (animals and vegetables) constitute another class of impurities of river water. But the public has formed a very erroneous notion of the extent and nature of this source of impurity, in consequence of the public exhibition in London of aquatic animals, by means of the solar and oxyhydrogen microscopes. The animals used on these occasions are collected in stagnant pools in the neighbourhood of the metropolis, and are not found in the water usually supplied for domestic use.

Recent microscopic investigations have shown that animals are liable to both vegetable and animal parasites.[3] Thus goldfish (*Cyprinus auratus*) often become covered with a white efflorescence, and, in consequence, languish and die. When examined by a microscope, this efflorescence is found to be a confervoid plant, and to consist of articulated, cellular tubes, some of which are filled with granules, and one or two nuclei. A similar growth sometimes occurs on efts (*Triton cristata*), by which the tails of these animals

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In the same work, Dr. Copland, in his evidence before the Committee of the House of Commons, states that water which percolates through soil abounding in animal matter becomes injurious to the health of the individuals using it. This fact, he says, "has been proved on many occasions, and especially in warm climates; and several very remarkable facts illustrative of it occurred in the Peninsular campaign. It was found, for instance, at Ciudad Rodrigo, where, as Sir James M'Grigor states in his account of the health of the army, there were 20,000 dead bodies put into the ground within the space of two or three months, that this circumstance appeared to influence the health of the troops, inasmuch as for some months afterwards all those exposed to the emanations from the soil, as well as obliged to drink the water from the sunk wells, were affected by malignant and low fevers, and by dysenteries, or fevers frequently putting on a dysenteric character. The digestive operations are affected by water abounding with putrid animal matter; so that burying in large towns affects the health of individuals—in the first place, by emanations into the atmosphere, and in the second place, by poisoning the water percolating through that soil."

[1] *An Investigation of the Properties of the Thames Water*, Lond. 1828.

[2] A similar change is reported to have occurred to water collected at St. Jago (see *Phil. Trans.* No. 268, p. 738, vol. xxii. 1701).

[3] For an account of vegetable parasites, see Robin, *Des Végétaux qui croissent sur l'Homme et sur les Animaux vivent*, Paris, 1847.

are gradually destroyed. Now it is by no means improbable that disease may be induced in a somewhat similar way in the human subject by the use of water containing the shreds or filaments of cryptogamic plants. This suspicion is strengthened by the case related by Dr. A. Farre[1] of a woman who passed by the bowels substances having the ordinary appearance of shreds of false membrane, but consisting entirely of confervoid filaments, probably belonging to the genus *Oscillatoria.* The patient drank the ordinary water which supplies London, and it is not improbable, therefore, she may have in this way imbibed the reproductive sporules. In the same way aquatic animals of various species may be occasionally swallowed.

TESTS OF THE USUAL IMPURITIES IN COMMON WATERS.—The following are the tests by which the presence of the ordinary constituents or impurities of common waters may be ascertained:—

1. EBULLITION.—By boiling, air and carbonic acid gas are expelled, while carbonate of lime (which has been held in solution by the carbonic acid) is deposited. The latter constitutes the fur or crust which lines tea-kettles and boilers.

2. PROTOSULPHATE OF IRON.—If a solution or crystal of this salt be introduced into a phial filled with the water to be examined, and the phial be well corked, a yellowish-brown precipitate (sesquioxide of iron) will be deposited in a few days, if oxygen gas be contained in the water (see *ante*, p. 268).

3. LITMUS.—This is a test for acids or alkalies. Blue litmus paper, or blue infusion of litmus or syrup of violets, is reddened by a free acid. Litmus paper or infusion of litmus, slightly reddened by an acid, has its blue colour restored by an alkaline or alkaline carbonate.

4. LIME WATER.—This is a test for carbonic acid, with which it causes a white precipitate (carbonate of lime) if employed before the water is boiled.

5. CHLORIDE OF BARIUM.—A solution of this salt usually yields, with well-water, a white precipitate, insoluble in nitric acid. This indicates the presence of sulphuric acid (which, in common water, is combined with lime, and sometimes with soda).

6. OXALATE OF AMMONIA.—If this salt yield a white precipitate, it indicates the presence of lime (usually in the form of carbonate and sulphate).

7. NITRATE OF SILVER.—If this occasion a precipitate insoluble in nitric acid, the presence of chlorine (usually as chloride of sodium or earthy chloride) may be inferred. Nitrate of silver may also be used to detect the existence of phosphoric acid in water. In his paper on the deep-well water of the London basin, Professor Graham[2] observes, that a small deposit, chiefly consisting of carbonate and phosphate of lime, takes place when this water is considerably evaporated; and the remaining liquid gives, with nitrate of silver, a precipitate of chloride and carbonate of silver, "which is white, without any shade of yellow; but if a portion of the water, amounting to an ounce or two, be evaporated to dryness in a platinum capsule, without removing the precipitate, and the heat afterwards continued so as to raise the temperature of the resulting dry saline water to low redness, then, on redissolving by distilled water, and adding nitrate of silver, a precipitate is obtained, in which the yellow colour of the phosphate of silver is very perceptible. The earthy phosphate is decomposed by ignition with the alkaline [carbonate] belonging to the water, and the soluble phosphate of soda is produced." Nitrate of silver is also used as a test of organic matter (see *ante*, p. 280).

8. PHOSPHATE OF SODA.—If the lime contained in common water be removed by ebullition and oxalic acid, or oxalate of ammonia, and to the strained and transparent water ammonia and phosphate of soda be added, any magnesia present will, in the course of a few hours, be precipitated in the form of the white ammoniacal phosphate of magnesia.

9. TINCTURE OF GALLS.—This is used as a test for iron, with solutions of which it forms an inky liquor (tannate and gallate of iron). If the test produce this effect on the water before, but not after, boiling, the iron is in the state of carbonate; if after as well as before, it is in that of sulphate. *Infusion of tea* may be substituted for infusion of galls, to which its effects and indications are similar. *Ferrocyanide of potassium* yields, with

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[1] *Microscopic Journal*, vol. ii. p. 189.

[2] *Memoirs of the Chemical Society*, vol. ii. p. 392.

solutions of the sesquisalts of iron, a blue precipitate, and with the protosalts a white precipitate, which becomes blue by exposure to the air.

10. HYDROSULPHURIC ACID *(Sulphuretted Hydrogen)*.—This yields a dark (brown or black) precipitate (a metallic sulphuret) with water containing lead or copper in solution. —*Hydrosulphuret of ammonia* or *sulphuret of potassium* occasions a dark or black precipitate or discolouration with water containing iron, as well as with that which contains either lead or copper in solution.

11. EVAPORATION AND IGNITION.—If the water be evaporated to dryness, and ignited in a glass tube, the presence of organic matter may be inferred by the odour and smoke evolved, as well as by the charring.—Another mode of detecting organic matter is by adding nitrate of lead to the suspected water, and collecting and igniting the precipitate; when globules of metallic lead are obtained if organic matter be present.[1]—The putrefaction of water is another proof of the presence of this matter.—Nitrate of silver has been before mentioned as a test (see *ante*, p. 280).

1. AQUA PLUVIALIS; *Aqua Pluvia; Aqua Imbrium; Rain Water.*—This is the purest of all natural waters. Its composition, however, varies somewhat in different situations, owing to the foreign substances floating in the atmosphere, and with which it becomes contaminated. It contains *air, carbonic acid, salts,* and *organic matter.*

Liebig[2] has shewn that rain water contains carbonate of ammonia, to which he ascribes its softness. Carbonate of lime is another constituent, as is also, according to Bergmann, chloride of calcium. The latter chemist also obtained traces of nitric acid. Zimmermann found oxide of iron and chloride of potassium in rain; but Kastner could discover no trace of iron in it, though he found meteoric iron and nickel in dew. Brandes detected various other inorganic substances, viz. chloride of sodium (principally), chloride of magnesium, sulphate and carbonate of magnesia, and sulphate of lime. He likewise mentions oxide of manganese. The putrefaction to which rain water is subject shews that some organic matter is present. The term *pyrrhin* (from πυρρός, *red*) has been applied by Zimmermann to an atmospheric organic substance which reddens solutions of silver.

At the commencement of rain, especially after the long-protracted drought, the water which falls contains more foreign matter than the rain water collected after several hours or days of continued rain. The first rain which falls is contaminated with carbonate of ammonia, various other salts (sulphates and chlorides), carbonaceous matters, &c. washed out of the atmosphere. Such water, therefore, should not be collected for pharmaceutical and chemical purposes.

The purest rain water is collected after a continued rain of several hours or days, and at a distance from houses. That which is collected from the roofs of houses is of course liable to contamination from various sources.

Whenever rain water is collected near large towns, it should be boiled and either strained or allowed to deposit its impurities before use. As it contains less saline impregnation than other kinds of natural waters, it is more apt to acquire metallic impregnation from leaden cisterns and water pipes.

SNOW WATER (*Aqua ex Nive; Aqua Nivalis*) is destitute of air and other gaseous matters found in rain; and hence fish cannot live in it. It has long been a popular, but erroneous opinion, that it was injurious to the health, and had a tendency to produce bronchocele. But this malady "occurs at Sumatra, where ice and snow are never seen; while, on the contrary, the disease is quite unknown in Chili and Thibet, although the rivers of these countries are chiefly supplied by the melting of the snow with which the mountains are covered."[1] Snow does not quench thirst; on the contrary, it augments it; and the natives of the Arctic regions "prefer enduring the utmost extremity of this feeling, rather than attempt to remove it by eating of snow."[2] When melted, however, it proves as efficacious as other kinds of water.

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[1] See Dr. Lamb's *Investigation of the Properties of Thames Water*, p. 11, 1828; also Clement, *Ann. de Chimie et Physiq.* t. iv. p. 282.

[2] *Organic Chemistry in its Application to Agriculture and Physiology*, edited by Lyon Playfair, Ph.D. Lond. 1840.

2. AQUA FONTANA; *Spring Water.*—This is rain water which, having percolated through the earth, reappears at the surface of some declivity. During its passage it almost always takes up some soluble matters, which of course vary according to the nature of the soil. Its constituents are similar to those of well water, which is also frequently termed spring water.

"For pharmaceutic use, spring water must be so far at least free of saline matter as not to possess the quality of hardness, or contain above a 6000th of solid matter."—*Ph. Ed.*

Under the name of *spring water* the Edinburgh College include also *well water*. The purity indicated in the Edinburgh Pharmacopœia for spring water is intended to apply to the springs of Scotland. Spring water of such purity is rare in England.

3. AQUA EX PUTEO; *Aqua Puteana; Well Water.*—This is water obtained by sinking wells. As it is commonly raised by means of a pump, it is frequently called *pump water*. The constituents of ordinary well water are similar to those of river water above mentioned; but the earthy salts (especially the sulphate of lime) are found in much larger quantity.

THE LONDON WELLS.—The wells in London[3] may be arranged in three classes: those in the gravel above the clay; those in the clay itself; and those which derive their supply from the strata below the clay.

1. *Wells in the diluvial gravel above the clay.*—These are shallow wells which, generally speaking, yield good drinking water, though the produce of some of them is rather hard and brackish. The supply which they yield is generally insufficient for the consumption of large manufactories.

2. *Wells in the London clay.*—The water obtained from the blue clay is exceedingly impure. It derives its great hardness from sulphate of lime, of which it is sometimes nearly a saturated solution. Sulphate of magnesia, sulphate of soda, sulphate of iron, and occasionally sulphuretted hydrogen, are also found in these waters. The supply of these wells is scanty.

3. *Wells which derive their supply from the strata below the clay.*—These wells derive their water from the sand and plastic clay contained, beneath the London clay, in the chalk basin. Many of the wells extend some distance into the chalk. Their depth varies in different localities from 100 to 500 feet or more. The water which these deep wells of the London basin supply is remarkable for its softness, derived from the presence of carbonate of soda, and for its containing phosphoric acid. It has been analysed by Professor Graham.[4] An imperial gallon obtained from the deep well in the brewery of Messrs. Combe and Delafield, Long Acre, contained 56·45 grains of solid matter, 100 parts of which gave

Carbonate of soda	20·70
Sulphate of soda	42·94
Chloride of sodium	22·58
Carbonate of lime	10·96
Carbonate of magnesia	0·92
Phosphate of lime	0·34
Phosphate of iron	0·43
Silica	0·79
	100·66

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[1] Paris, *Pharmacologia*, 6th edit. vol. i. p. 79.

[2] *Narrative of a Second Voyage in Search of a North-west Passage; and of a Residence in the Arctic Regions during the years* 1829, 1830, 1831, 1832, *and* 1833, p. 366. Lond. 1835.

[3] For a notice of the Wells in London, see Conybeare and Phillips's *Outlines of the Geology of England and Wales*; also the *Quarterly Journal of Science*, vol. xiv. p. 145, 1823.

[4] *Memoirs of the Chemical Society*, vol. ii. p. 392.

It is obvious, therefore, that the deep well water of the London basin contains nearly three times as much solid matter in solution as does Thames water (see *infra*).

Artesian Wells.—These are vertical, cylindrical borings[1] in the earth, through which water rises, by hydrostatic pressure, either to the surface (*spouting* or *overflowing wells*), or to a height convenient for the operation of a pump.[2] They have been denominated Artesian from a notion that they were first made in the district of Artois, in France. It is probable, however, that they were known to the ancients, for a notice of them is said to occur in Olympiodorus.[3] Proposals have been made for supplying London with water by these wells, which would derive their water from the stratum of sand and plastic clay placed between the London clay and the chalk basin.[4] But it does not appear that a sufficient supply can be obtained in this way.[5]

4. AQUA EX FLUMINE; *Aqua Fluvialis; River Water.*—This is a mixture of rain and spring water. When deprived of the matters which it frequently holds in suspension, its purity is usually considerable. The following are the solid constituents of the waters of the Thames and Colne, at different localities, according to the analyses of Mr. R. Phillips[6]:—

QUANTITY OF WATER. 1 Gallon = 10 lbs. Avoirdupois, at 62° F., or 70000 grs. Avoirdupois.	THAMES WATER.			COLNE WATER.		
	Brentford. Source of the Grand Junction Water Works Company.	***Barnes.*** Source of the West Middlesex Water Works Company.	***Chelsea.*** Source of the Chelsea Water Works Company.	***Otterpool.*** Spring, near Bushey.	***Main spring*** in the valley that supplies the Colne	***Colne*** itself.
	grs.	grs.	grs.	grs.	grs.	grs.
Carbonate of Lime	16·000	16·900	16·500	18·800	19·300	18·100
Sulphate of Lime .... Chloride of Sodium	3·400	1·700	2·900	2·500	2·500	3·200
Oxide of Iron .... Silica .... Magnesia .... Carbonaceous matter	very minute portions	ditto	ditto	ditto	ditto	ditto
Solid matter held in solution	19·400	18·600	19·400	21·300	21·800	21·300
Mechanical Impurity......	0·368	0·368	0·238	0·185	0·262	0·126
Total solid matter ..	19·768	18·968	19·638	21·485	22·062	21·426

No notice is taken in these analyses of the gaseous constituents (air and carbonic acid) of river water.

Thames water taken from the middle of the river at Twickenham, two hours after high water, on the 16th of December, 1847, had a temperature of 49°·1 Fahr., and the specific gravity of 1·0003. An imperial gallon of it contained 22·48995 grains of solid matter, consisting of carbonate of lime, soluble organic matter, insoluble organic matter, sulphate of soda, chloride of calcium, carbonate of magnesia, sulphate of potash, sulphate of lime, silicic acid, and free carbonic acid.[7]

Supply of Water to the Metropolis.[8]—London is supplied with water by eight water companies, six of which derive their water from the Thames. The East London

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[1] For a description of the mode of boring and of the tools used, see Ure's *Dictionary of Arts, Manufactures, and Mines*, p. 57. London, 1839.

[2] In the *Penny Cyclopædia*, art. *Artesian Wells*, is a popular and interesting account of these wells.

[3] Passy, *Description Géologique du Département de la Seine-Inférieure*, p. 292. Rouen, 1832.

[4] See an interesting account of Artesian Wells, by Mr. Webster, in the *Athenæum* for 1839, p. 131.

[5] *Ibid.*; also, *Transactions of the Institution of Civil Engineers*, vol. iii. part iii.

[6] *Report from the Select Committee of the House of Lords, appointed to inquire into the supply of Water to the Metropolis*, p. 91, 1840; See also Dr. Bostock's analysis in the *Report of the Commissioners appointed to inquire into the state of the supply of Water in the Metropolis*, 1828.

[7] G. F. Clarke, in the Proceedings of the Chemical Society (*Pharmaceutical Journal*, vol. vii. p. 591).

[8] See the *Report of the Commissioners appointed by His Majesty to inquire into the state of the supply of Water in the Metropolis* (*Quarterly Journal of Science*, April 1828).

Company derives its water from the river Lea. The New River Company derives its principal supply from a spring at Chadwell, between Hertford and Ware, and from an arm of the river Lea. The following was the amount supplied to the metropolis in 1828:—

		Gallons per diem.
North side of the Thames	New River	13,000,000
	East London	6,000,000
	Grand Junction	2,800,000
	West Middlesex	2,250,000
	Chelsea	1,760,000
South side of the Thames	Lambeth	1,244,000
	Vauxhall or South Lambeth	1,000,000
	Southwark	720,000
	Total daily supply	28,774,000

5. AQUA EX LACU; *Lake Water.*—This is a collection of rain, spring, and river water, usually contaminated with putrefying organic matter.

6. AQUA EX PALUDE; *Marsh Water.*—This is analogous to lake water, except that it is altogether stagnant, and is more loaded with putrescent matter. The sulphates in sea and other waters are decomposed by putrefying vegetable matter, with the evolution of sulphuretted hydrogen: hence the intolerable stench from marshy and swampy grounds liable to occasional inundations from the sea (see p. 69, foot note).

2. *Aqua Marina.—Sea Water.*

(Aqua Maris.)

Under this head are included the waters of the ocean and of those lakes, called inland seas, which possess a similar composition. The Dead Sea, however, differs exceedingly in its nature from sea water, and might properly be ranked amongst mineral waters.

The water of the Dead Sea contains, according to Marcet's[1] analysis, 24·6 per cent. of saline water, and has the extraordinary density of 1·211. Its constituents are as follows:—

Muriate of lime	3·920
" magnesia	10·246
" soda	10·360
Sulphate of lime	0·054
Water	75·420
	100·000

The quantity of solid matter varies considerably in different seas, as the following statement from Pfaff[2] proves:—

10,000 *Parts of Water of*		*Solid Constituents.*
The Mediterranean Sea		410 grs.
English Channel		380 "
German Ocean	At the Island of Föhr	345 "
	" " Norderney	342 "
	In the Frith of Forth	312 "
	At Ritzebüttel	312 "
Baltic Sea	At Apenrade, in Sleswick	216 "
	At Kiel, in Holstein	200 "
	At Doberan, in Mecklenberg	168 "
	At Travemünde	167 "
	At Zoppot, in Mecklenberg	76 "
	At Carlshamm	66 "

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[1] Nicholson's *Journal*, xx. 25.

[2] Schwartze's *Allgemeine und specielle Heilquellenlehre*, 2te Abt. S. 186. Leipsig, 1839.

We shall not be far from the truth if we assume that the average quantity of saline matter is 3½ per cent., and the density about 1·0274.

The composition of sea water, according to Schweitzer[1] and Laurens, is as follows:—

Constituents.	*Of the English Channel.* (SCHWEITZER.) Grains.	*Sea Water of the Mediterranean.* (LAURENS.) Grains.
Water	964·74372	959·26
Chloride of sodium	27·05948	27·22
" potassium	0·76552	0·01
" magnesium	3·66658	6·14
Bromide of magnesium	0·02929	—
Sulphate of magnesia	2·29578	7·02
" lime	1·40662	0·15
Carbonate of lime	0·03301	and Magnesia 0·20
	1000·00000	1000·00

Schweitzer also detected distinct traces of iodine and ammonia.

Iodine has been found in the Mediterranean by Balard.

Forchammer[2] asserts that though the total solid contents of the water of the Atlantic vary from 3·57 (German Sea) to 3·66 (tropics) per cent. of the water, yet that the relative proportion of the salts varies but little.

PHYSIOLOGICAL EFFECTS AND USES.—Sea water, taken internally, excites thirst, readily nauseates, and, in full doses, occasions vomiting and purging. The repeated use of it, in moderate doses, has been found beneficial, on account of its alterative and resolvent operation in scrofulous affections, especially glandular enlargements and mesenteric diseases. Its topical action is more stimulant than common water. It is used as an embrocation in chronic diseases of the joints. Employed as a bath, it more speedily and certainly causes the reaction and glow; and consequently the sea-water bath may be used for a longer period, without causing exhaustion, than the common water bath. In other respects its effects, as a bath, are similar to those of common water (see *ante*, pp. 20 and 28). It is a popular opinion, which is perhaps well founded, that patients are less likely to take cold after the use of salt water, as a bath, than after the employment of common water.[3]

Fresh water may be obtained from sea water either by congelation or distillation. In freezing, the pure water only congeals, not the saline matters: and hence the ice of the Polar seas yields fresh water. By distillation, pure wholesome fresh water may be obtained from sea water; but hitherto various inconveniences and objections have prevented mariners being supplied with fresh water from this source.[4]

From sea water is procured chloride of sodium and sulphate of magnesia.

BALNEUM MARIS FACTITIUM; *Artificial Sea Water Bath.*—A cheap substitute for a sea water bath is prepared by dissolving common salt in water in the proportion of five ounces avoirdupois to every wine gallon of water.

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[1] *Lond. and Edin. Phil. Mag.* vol. xv, p. 51, July 1839.

[2] *Reports of the British Association*, 1846, p. 90.

[3] On the medicinal properties of sea water, consult Logan's *Observations on the Effects of Sea Water in Scurvy and Scrophula*, Lond. 1770; and Dr. R. White, on *The Use and Abuse of Sea Water*, Lond. 1775.

[4] Clark's *Patent Improved Pyro-hydro-pneumatic Apparatus for easily converting Sea Water into Fresh*, is a convenient form of still adapted for use at sea.

3. *Aquæ Minerales.—Mineral Waters.*

HISTORY.—Mineral waters were known to mankind in the most remote periods of antiquity, and were employed medicinally, both as external and internal agents, for the prevention, alleviation, and cure of diseases. Homer[1] speaks of tepid and cold springs. The Asclepiadæ, or followers of Æsculapius, erected their temples in the neighbourhood of mineral and thermal waters.[2] Hippocrates[3] speaks of mineral waters, though he does not prescribe them, when speaking of particular diseases. Pliny[4] notices their medicinal properties.

NATURAL HISTORY.—The principal source of mineral waters is the atmosphere, from which water is obtained in the form of rain, snow, hail, and dew, and which, after percolating a certain portion of the earth, and dissolving various substances in its passage, reappears on the surface at the bottom of declivities (*spring water*), or is procured by sinking pits or wells (*well water*). But springs are sometimes observed under circumstances which are inconsistent with the supposition of their atmospheric origin. "The boiling springs which emerge on the verge of perpetual snows, at an altitude of 13,000 feet above the level of the sea, as in the Himalayahs, cannot be derived from the atmosphere, not to mention the peculiar relations of the Icelandic Geysers."[5] Other sources, therefore, have been sought for, and the writer just quoted enumerates three, viz. the focus of volcanic activity, the great mass of the ocean, or other masses of salt water and subterranean reservoirs.

Considered with reference to their temperature, mineral waters are divided into *cold* and *hot*. The hot or thermal waters are those which possess a temperature more or less elevated above the mean of the latitude or elevation at which they are found, and the changes of which, if any, observe no regular periods coincident with the revolutions of the seasons. Three causes have been assigned as the source of the heat of mineral waters, viz. volcanic action now in existence; volcanic action now extinguished, but the effects of which still remain; and a central cause of heat, which increases as we descend from the surface to the interior of the earth.[6]

The *Geysers*, or boiling springs, of Iceland, are evidently connected with volcanic action. They are intermittent fountains, which throw up boiling water and spray to a great height into the air.[7]

The origin of the saline and other constituents is another interesting topic of inquiry connected with the natural history of mineral springs. As water in its passage through the different strata of the earth must come in contact with various substances which are soluble in it, we refer certain constituents of mineral waters to solution and lixiviation merely; as chloride of sodium, carbonates of lime and magnesia, iodides and bromides of sodium and magnesium, iron, silica, &c. Chemical action must, in some cases, be the source of other constituents. Thus sulphuretted hydrogen is probably produced by the action of water on some metallic sulphuret (especially iron pyrites); sulphurous or sulphuric acid, from the oxidation and combustion of sulphur, free or combined. The carbonic acid found in the acidulous or carbonated waters is referable to the decomposition of carbonate of lime, either by heat or by the action of sulphuric acid. Hydrochloric acid is doubtless produced by the decomposition of some chloride (probably chloride of sodium or sal ammoniac). Carbonate of soda must also be considered as the product of some chemical process; thus, that found in the natron lakes of Egypt is supposed to be formed by the action of chloride of sodium on carbonate of lime.[1] "The different orifices of the Karlsbad Sprudel discharge annually about 13,000 tons of carbonate of soda and 20,000 of the sulphate in the crystallized state;"[2] but a "very simple calculation is sufficient to shew that the Donnersberg alone, the loftiest of the Bohemian Mittelgebirge, a cone of clinkstone 2,500 feet in elevation, contains soda enough to supply the Karlsbad waters alone for more than 30,000 years."[3]

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[1] *Iliad*, xxii. 147.

[2] Sprengel, *Hist. de Médec.* par Jourdan, t. 1er, p. 144.

[3] *De aeribus, aquis, locis.*

[4] *Hist. Nat.* lib. xxxi.

[5] Gairdner's *Essay on Mineral and Thermal Springs*, p. 289.

[6] Gairdner, *op. cit.*

[7] For further information concerning them, I must refer to Sir G. S. Mackenzie's *Travels in Iceland during the Summer of* 1810, Edinb. 1811; and to Barrow's *Visit to Iceland, by way of Tronyem, &c. in the Summer of* 1834, Lond. 1835.

CLASSIFICATION.—Mineral waters may be classified according to their temperature, their chemical composition, or their medicinal properties. But hitherto no satisfactory classification has been effected by any of these methods, nor perhaps can it be formed.

The method adopted by Paracelsus and the alchymists was to divide mineral waters according to their temperature into the two great classes of *hot* and *cold*, and to sub-divide each of these according to their supposed constituents. The following is Dr. Gairdner's classification according to this method:—

SERIES I.—THERMAL.

CLASS

1. SULPHUREOUS. Predominant constituent, *Sulphuretted Hydrogen*:
   e. g. Barèges, Aix-la-Chapelle.
2. ALKALINE. Pred. const. *Carbonate of Soda*:
   e. g. Ems, Teplitz, Vichy, Mont-d'Or, Ischia.
3. PURGING. Pred. const. *Sulphate of Soda*:
   e. g. Karlsbad, d'Ax, Pisa.
4. SALINE. Pred. const. *Chloride of Sodium*:
   e. g. Wiesbaden, Bourbon l'Archambault, Cività Vecchia, Baden in Baden.
5. CALCAREOUS. Pred. const. *Carbonate* or *Sulphate of Lime*:
   e. g. Bath, Buxton, St.-Allyre.
6. SILICEOUS. Pred. const. *Silica*:
   e. g. Geyser, Chaudes Aigues, Luxueil, Mariara.
7. PURE. Little or no impregnation:
   e. g. Matlock, Vic en Carlades.

SERIES II.—COLD.

CLASS

1. SULPHUREOUS. Predominant constituent, *Sulphuretted Hydrogen*:
   e. g. Harrowgate, Moffat, Nenndorff.
2. ACIDULOUS. Pred. const. *Carbonic Acid Gas*:
   e. g. Pyrmont, Selters, Asciano.
3. ALKALINE. Pred. const. *Carbonate of Soda*:
   e. g. Vals, Bilin, Malvern.
4. PURGING. Pred. const. *Sulphate of Soda*:
   e. g. Cheltenham, Franzensbad, Marienbad.
5. SALINE. Pred. const. *Chloride of Sodium*:
   e. g. Leamington, Rennes, Bourbonne-les-Bains.

(5.) BRINE SPRINGS. Pred. const. *Chloride of Sodium*:
   e. g. Ashby-de-la-Zouch, Kreuznach, Ischl, Bex.

6. CHALYBEATE. Pred. const. *Oxide of Iron*:
   e. g. Tunbridge, Spa.
7. ALUMINOUS CHALYBEATE. Pred. const. *Sulphates of Iron and Alumina*:
   e. g. Isle of Wight, Hartfell, Alexisbad.
8. BITTER. Pred. const. *Sulphate of Magnesia*:
   e. g. Saidschütz, Seidlitz, Epsom.

This arrangement is objectionable on two grounds: the two series of thermal and cold waters pass into each other by almost insensible gradations; and secondly, waters of analogous chemical composition, and, therefore, of similar medicinal properties, are separated on account of their difference of temperature.

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[1] Berthollet, *Essai de Statique Chimique*, 1er part. p. 406.

[2] Gairdner, *op. cit.* p. 325.

[3] *Ibid.* p. 338.

The classification which I shall adopt is convenient on account of its simplicity and practical utility. It consists in grouping mineral waters in four classes, respectively termed *chalybeate, sulphureous, acidulous,* and *saline.*

CLASS 1. CHALYBEATE OR FERRUGINOUS WATERS.

(Aquæ ferruginosæ seu martiales.)

These are mineral waters whose predominating or active principle is *iron.* Most mineral waters contain this metal, but the term chalybeate is not applied to them unless the quantity of iron be considerable in proportion to the other constituents.

The quantity of oxide of iron contained in different waters is shewn by the following table:—

DR. M. GAIRDNER'S TABLE OF THE QUANTITY OF OXIDE OF IRON CONTAINED IN CHALYBEATE WATERS.

	10,000 *Grs. of the Water.*	*Grs. of Oxide of Iron.*	*Authority.*
THERMAL	Bath in England	0·0271	R. Phillips.
	Bourbon l'Archambault in France	2·579	Patissier.
	Mont-d'Or in ditto	0·10	Berthier.
	Vichy in ditto	1·385	Longchamps.
	St.-Nectaire in ditto	0·14	Berthier.
	Chaudes Aigues in ditto	0·15	Ditto.
	Champagne in ditto	0·1573	Patissier.
	Karlsbad Sprudel in Bohemia	0·022	Berzelius.
	Teplitz Steinbad in ditto	0·03	Ditto.
COLD	Tunbridge in England	0·381	Scudamore.
	Harrowgate (Oddy's saline chalyb.) in ditto	0·411	Ditto.
	Isle of Wight (aluminous chalyb.) in ditto	14·79	Marcet.
	Holywell, Lancashire, in ditto	2·396	perox. ir. Woolworth.
	Hartfell Spa, near Moffat, in Scotland	0·825	Thomson.
	Ditto, No. 2	34·2	Ditto.
	Vicar's Bridge, near Dollar, in ditto	312·0	Connel^{l}.
	Dunblane in ditto	0·233	Murray.
	Forges in France	1·128	Robert.
	Aumale in ditto	2·50	Diezengremel.
	Passy in ditto	0·679	Deyeux.
	Vals in ditto	0·06	Berthier.
	Alexisbad, Bernburg, in Germany	2·348	Graefe.
	Buckowina in Silesia (lower spring)	2·090	Lachmund.
	Liebenstein in Thuringia	1·66	Trommsdorff.
	Godelheim (bathing spring)	1·489	Witting.
	Lauchstadt	1·018	
	Spa	0·746	Monheim.
	Pyrmont (drinking spring)	0·611	Brandes.
	Kissengen	0·421	Vogel.
	Bruckenau in Franconia	0·210	Schipper.
	Karlsbad (acidulous spring)	0·03	Berzelius.
	Königswart (drinking spring)	0·38	Ditto.
	Bilin	0·10	Reuss.
	Geilnau on the Lahn	0·128	Bischof.
	Fachingen on ditto	0·077	Ditto.
	Selters in Nassau	0·124	Ditto.
	Marienbad, Caroline well	0·369	Steinman and Reuss.
	Engistein, Canton of Bern in Switzerland	0·875	Pagenstecher.
	Schmerikon, Canton of Gallen in ditto	1·086	Hütteuschmidt.
	St. Catarina, Canton Veltlin in ditto	2·466	Demagri.
	Lipewsk in Russia	1·0 to 2·0	Scherer.
	Ballstown, New York, United States	3·332	Hosack.

This can scarcely be called a true mineral water, being somewhat analogous to the pools in

Chalybeate waters have an inky or styptic taste, and become purplish-black on the addition of tannic or gallic acid (or substances, as galls and tea, which contain one or both of these acids). Waters which contain the protosalts of iron yield, on the addition of ferrocyanide of potassium, a white or blueish-white precipitate, which becomes blue by exposure to the air. Those which contain the sesquisalts of iron give a blue precipitate with ferrocyanide of potassium, and become red on the addition of sulphocyanide of potassium.

Chalybeate waters are of two kinds,—carbonated and sulphated.

Order 1. Carbonated Chalybeate Waters (*Aquæ ferruginosæ carbonicæ*).—These waters contain the carbonate of the protoxide of iron. By exposure to the air, or by boiling, they attract oxygen, evolve carbonic acid, and deposit the whole of the iron in the form of sesquioxide.

When the carbonate of iron is associated with a large quantity of carbonic acid, which renders the waters brisk, sparkling, and acidulous, they are denominated *highly carbonated* or *acidulo-carbonated chalybeates*, or *acidulo-ferruginous waters*. The Pyrmont (Trinkquelle or drinking spring), Schwalbach, and Spa (Pouhon) waters are of this kind.

When, however, the quantity of carbonic acid is not large, and the waters do not sparkle in the glass, they are termed *simply carbonated chalybeates*, or, from the earthy and alkaline salts which they contain, *saline carbonated chalybeates*. The waters of Tunbridge Wells, Oddy's saline chalybeate at Harrowgate, and the Islington Spa near London, are of this kind.

Osann[1] and Schwartze[2] divide the carbonated chalybeates into the *earthy-saline* (*e. g.* Pyrmont), the *alkaline-saline* (*e. g.* Franzensbad or Egar), the *alkaline-earthy* (*e. g.* Spa), and the *earthy* (*e. g.* Wildungen).

Order 2. Sulphated Chalybeates. (*Aquæ vitriolicæ*).—These contain sulphate of iron, and some of them also contain chloride of iron. Neither exposure to the air nor boiling precipitates all the iron, and in this respect the sulphated chalybeates are distinguished from the carbonated ones.

Some of them contain sulphate of alumina, and are denominated *aluminous sulphated chalybeates*. Of these the Sand Rock Spring in the Isle of Wight, the Strong Moffat Chalybeate, Vicar's Bridge Chalybeate, and the Passy waters, are examples. The waters of Buckowina, in Silesia, are of this kind; but they contain also chloride of iron.

The Cransac waters contain, besides the sulphate of the sesquioxide of iron and sulphate of alumina, a considerable quantity of sulphate of manganese; in consequence of which they have been denominated the *sulphated ferro-manganesian waters*.[3]

Those sulphated chalybeates which are devoid of sulphate of alumina, may be termed *simply sulphated chalybeates*. The Alexisbad or Selken-Brunnen contain both sulphate and chloride of iron, but are devoid of sulphate of alumina.

The chalybeate waters operate in a similar manner to the other ferruginous compounds already noticed (see *ante*, p. 188).

The acidulated carbonated chalybeates sit more easily on the stomach than other ferruginous agents, in consequence of the excess of carbonic acid which they contain.

The aluminous chalybeates are very apt to occasion cardialgia, especially if taken in the undiluted state.

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copper mines of England and Sweden, which hold copper in solution—a substance not found in true mineral springs. As it is, however, an example of a purely natural process, I have deemed it worthy of a place among the other waters.—M. G.

[1] *Physical. u. Med. Darstellung der Heilquellen.* 3 Bde. 1842.

[2] *Allgemeine und specielle Heilquellenlehre*, fol. Leipzig, 1839.

[3] See *Notice sur les Eaux Minérales Naturelles de Cransac, département de l'Aveyron; Eaux Ferro-Manganésiennes, sulfatées*, par le Dr. Ducoux (de Blois). Paris, 1847. (An English translation of the preceding, with some additions and modifications, entitled *The Mineral Waters and Vapour Baths of Cransac*, London, 1847); also, *Traité sur la Nature et les Propriétés des Eaux Minérales et Etuves de Cransac*, par M. J. F. V. Murat, 3me éd. Rodez, 1843.

The use of chalybeate waters is indicated in cases of debility, especially when accompanied with that condition of system denominated anæmia. They have long obtained a high celebrity for the relief of complaints peculiar to the female sex. Their employment is contra-indicated in plethoric, inflammatory, and febrile conditions of system.

CLASS 2. SULPHUREOUS OR HEPATIC WATERS.

(Aquæ Sulphureæ seu Hepaticæ.)

These waters are impregnated with hydrosulphuric acid (sulphuretted hydrogen); in consequence of which they have the odour of rotten eggs, and cause black precipitates (metallic sulphurets) with solutions of the salts of lead, silver, copper, bismuth, &c. Those sulphureous waters which retain, after ebullition, their power of causing these precipitates, contain a sulphuret (hydrosulphuret), usually of calcium or sodium, in solution. All the British sulphureous waters are cold, but some of the continental ones are thermal. The most celebrated sulphureous waters of England are those of Harrowgate;[1] those of Scotland are Moffat and Rothsay; of the continent, Enghien, Barèges, Aix (near Geneva), Aix-la-Chapelle[2] (or Aachen), and Baden.

DR. M. GAIRDNER'S TABLE OF THE QUANTITY OF SULPHURETTED HYDROGEN IN SULPHUREOUS WATERS.

	100 *Cubic inches of the Water of*	*Cub. inches of Gas.*	*Authority.*
THERMAL	Barèges in the Pyrenees, contains	20·0	Lüdemann.
	Cauterets in ditto	50·0	Ditto.
	St. Sauveur in ditto	16·6	Ditto.
	Schinznach in C. Aargau in Switz.	30·11	Peschier.
	Aachen in the Lower Rhine	45·78	Monheim.
	Warmbrunn in Silesia	17·17	Osann.
	Landeck in county of Glatz	14·88	Ditto.
	Baden near Vienna	11·83	Ditto.
COLD	Harrowgate in England (old well)	5·94	Scudamore.[3]
	Moffat in Scotland	7·58	Thomson.
	Strathpeffer in ditto (upper well)	9·44	Ditto.
	Enghien in France	1·60	Longchamps
	Nenndorff in Hesse	40·90	Osann.
	Winslar in Hanover	51·51	Ditto.
	Eilsen in Lippe	27·21	Ditto.
	Meinberg in ditto	30.91	Ditto.
	Weilbach in Nassau	22.32	Ditto.[4]
	Berka in Thuringia	20·60	Ditto.
	Bocklet in Franconia	17·17	Ditto.
	Doberan in Mecklenburg	18.20	Ditto.
	Bentheim in Germany	15·45	Ditto.
	Sironabad in Hesse	2·63	Büchner.
	Dinkhold in Nassau	8·6	Kolb.

The sulphureous waters have been divided into four kinds, viz. the *alkaline-muriatic* (*e. g.* Aix-la-Chapelle), the *alkaline-saline* (*e. g.* Warmbrunn and Weilbach), the *earthy-saline* (*e. g.* Enghien), and the *ferruginous-saline* (*e. g.* Neumarkt and Rosenheim).

The general operation of the sulphureous waters is stimulant, and is adapted for chronic complaints.[1] They are supposed to possess a specific power over the cutaneous and uterine systems. They are employed both as external and internal agents; in chronic skin diseases (as lepra, psoriasis, scabies, pityriasis, herpes, &c.); in derangements of the uterine functions (amenorrhœa and chlorosis); in old syphilitic cases; in chronic rheumatism and gout; and in other diseases in which sulphur or its compounds have been found serviceable, (see *ante*, p. 183). On account of their stimulant effects, they are contra-indicated in all plethoric and inflammatory conditions of the system, and their employment requires caution, especially in weak and irritable constitutions.

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[1] See Dr. A. Hunter's *Treatise on the Mineral Waters of Harrowgate*, London, 1830.

[2] See Wetzlar's *Description of the Mineral Springs of Aix-la-Chapelle and Borcette*, 1842.

[3] I have not admitted the waters of Cheltenham into this list, in consequence of the extreme inconstancy of the sulphureous impregnation. Other reasons, however, render it very doubtful if any of the analyses of some of the recent springs represent their *natural* composition.—M. G.

[4] 30·9 Creve (*Stifft's Nassau*, p. 577).—M. G.

CLASS 3. ACIDULOUS OR CARBONATED WATERS.

(Aquæ Acidulæ.)

These waters owe their remarkable qualities to carbonic acid gas, which gives them an acidulous taste, a briskness, a sparkling property, and the power of reddening litmus slightly, but fugaciously, and of precipitating lime and baryta waters. When they have been exposed to the air for a short time, this gas escapes from them, and the waters lose their characteristic properties.

Most mineral and common waters contain a greater or less quantity of free carbonic acid. Ordinary spring or well waters do not usually contain more than three or four cubic inches of carbonic acid gas in 100 cubic inches of water. Dr. Henry found, in one experiment, 3·38 inches.[2] But the waters called acidulous or carbonated contain a much larger quantity. Those which have from 30 to 60 cubic inches of gas are considered rich; but the richest have from 100 to 200 or more inches.[3] Alibert[4] states that the waters of Saint-Nectaire contain 400 cubic inches in 100 of the water.

Most of the waters of this class contain carbonate or bicarbonate of soda: these are termed *acidulo-alkaline*. The Selters[5] (often called Seltzer), Altwasser, Saltzsbrunn, Reinerz, and Pyrmont (acidulous) waters, are of this kind. Frequently they contain carbonate of the protoxide of iron also: they are then termed the *acidulous carbonated chalybeates*, which have been already noticed (see *ante*, p. 297).

The only acidulous or carbonated spring in Great Britain is that of Ilkeston, near Nottingham, and which has been described by Mr. A. F. A. Greeves[6] and by Dr. T. Thomson.[7]

The acidulous or carbonated waters have been divided into four kinds, viz. the *alkaline-muriatic* (*e. g.* Selters); the *earthy muriatic* (*e. g.* Kissingen [Maxbrunnen]); the *earthy-alkaline* (*e. g.* Salzbrunn); and the *ferruginous* (*e. g.* Geilnau).

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[1] See some *Observations on the Efficacy of Sulphureous Waters in Chronic Complaints*, by Dr. J. Armstrong, in his *Practical Illustrations of the Scarlet Fever*, 2d edit. Lond. 1818.

[2] Thomson's *System. Chem.* vol. iii. p. 193, 6th edit.

[3] Gairdner, *op. cit.* p. 30.

[4] *Nouveaux Élémens de Thérapeutique*, tom. 3me, p. 517, 5me éd.

[5] See some *Experiments relative to the Analysis and Virtues of Seltzer Water*, by Dr. Brocklesby, in the *Medical Observations and Inquiries*, vol. iv. p. 7, 2d edit. Lond. 1772.

[6] *Account of the Medicinal Water of Ilkeston*, 1833.

[7] *Cyclopædia of Practical Medicine*, art. *Waters, Mineral.*

DR. M. GAIRDNER'S TABLE OF THE QUANTITY OF CARBONIC ACID IN ACIDULOUS WATER.

	100 *Cubic Inches of Water of*	*Cub. Inches of Gas.*	*Temp.*	*Authority.*
THERMAL......	Bath in England, contains	4·16	114° F.	R. Phillips.
	Bristol in ditto	12·99	74	Carrick.
	Buxton in ditto	0·649	82	Scudamore.
	St.-Nectaire in France	400·0	75	Alibert.[1]
	Karlsbad in Bohemia	110·0	165	Berzelius.
	Gurgitello in Ischia	89·14	122	Giudice.[2]
	Carratraca in Spain	10·70	66	Alibert.
	Maschuka in the Caucasus	60·9	118	Hermann.
	Eisenberg in ditto	32·7	103	Ditto.
	Petersquellen in ditto	2·0	195	Ditto.
	Schlangenbad in Nassau (Schachtbrun)	6·0	87	Kastner.
	Ems in ditto (Kränchesquelle)	59·9	86	Ditto.
	Ditto (at Wall of Lahn)	42·1	123	Ditto.
	Wiesbaden in ditto (No. 1)	19·7	158	Ditto.
COLD	Tunbridge in England	3·485	...	Scudamore.[3]
	Harrowgate in ditto (old sulphur well)	4·125	...	Ditto.
	Cheltenham in ditto (old well)	12·50	...	Fothergill, 1788.
	Pitcaithly in Scotland	3·463	...	Murray.
	Andabra in France	100·0	...	Berard.
	Enghien les Bains in ditto	0·674	...	Longchamps.[4]
	Godelheim in Germany	224·9	...	Witting.
	Cudowa in county of Glatz	202·6	...	Mogalla.
	Pyrmont in Germany	151·1	...	Brandes.
	Königswarth in Bohemia	139.1	...	Wetzler.
	Schwalheim in the Wetterau	129·0	...	Wurzer.
	Bocklet in Franconia	112·5	...	Vogelmann.
	Franzensbad in Bohemia	88·67	...	Trommsdorff.
	Geilnau on the Lahn	163·2	...	Bischof.
	Fachingen on ditto	134·8	...	Ditto.
	Selters in Nassau (Nieder)	108.7	...	Ditto.
	Liebenstein in Thuringia	109·9	...	Trommsdorff.
	Tarasp in Switzerland	109·9	...	Capeller.
	Kissingen in Germany	85·85	...	Vogel.
	Imnau in Wurtemburg	89·28	...	Kielmayer.
	Alexandersbad	94·09	...	Hildebrandt.
	Bilin in Bohemia	74·69	...	Reuss.
	Schwalbach in Nassau	73·83	...	Rube.
	Spa in Belgium	74·45	...	Monheim.
	Ballstown, State of New York	300·0	...	Hosack.
	Kislawodsk in the Caucasus	151·2	...	Hermann.
	Dinkhold in Nassau	143·9	...	Kolb.
	Oberlahnstein in ditto	55·6	...	Amburger.
	Marienfels in ditto	92·5	...	Kastner.
	Soden in ditto	88·0	...	Meyer.
	Cronberg in ditto	106·2	...	Ditto.
	Montabaur in ditto	55·8	...	Jacobi.
	Braubach in ditto (Salzborn)	58·4	...	Bruckmann.
	Langenschwalbach (Weinbruun)	89·1	...	Kastner.
	Marienbad in Bohemia (Kreutzbr.)	125·0	...	Struve.
	Saidschütz in ditto	20·0	...	Ditto.
	Püllna in ditto	6·9	...	Ditto.[5]

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[1] I have assumed the coldest spring to be that which contains this large quantity of gas, which is not particularly specified; there are seven springs, ranging from 74° to 104° F.—M. G.

[2] Viaggio Medico. Half of the acid escapes at 144°, and the whole at 167°.—M. G.

[3] After being heated to 144° F. it contained 2·736.—M. G.

[4] Parts by Weight in 10,000 of water.—M. G.

[5] In all these instances the carbonic acid was obtained by boiling, which expels not only the acid which is in an uncombined state in the natural water, but also the excess, which goes to convert the carbonates of acidulous water into bicarbonates.—M. G.

Those acidulous waters which owe their medicinal activity principally to the carbonic acid which they contain, act chiefly on the digestive, renal, and nervous systems; but their effects are transient. They are cooling, refreshing, and exhilarating, and frequently relieve nausea. They augment and alter the renal secretion. Sometimes they occasion a sensation of fulness in the head, or even produce slight temporary intoxication. They are used in some disordered conditions of the digestive organs, especially when connected with hepatic derangement, in dropsical complaints, in uterine affections, and in various other cases, which will be more fully noticed when treating of carbonic acid.

When the acidulous waters contain the protocarbonate of iron, their effects and uses are analogous to those of the ferruginous springs already noticed.

The acidulo-alkaline waters are useful in the lithic acid diathesis, in gout and rheumatism, &c.

The acidulous or carbonated waters are considered to be objectionable in febrile, inflammatory, and plethoric subjects.

CLASS 4. SALINE WATERS.

(Aquæ Salinæ.)

These waters owe their medicinal activity to their saline ingredients; for although they usually contain carbonic acid, and sometimes oxide of iron or hydrosulphuric acid, yet these substances are found in such small quantities as to contribute very slightly only to the medicinal operation of the water.

Saline mineral waters may be conveniently divided into five orders, founded on the nature of the predominating ingredient.

Order 1. Purging Saline Waters.—The leading active ingredient of the waters of this order is either the sulphate of soda or the sulphate of magnesia; but the chlorides of calcium and magnesium, which are usually present, contribute to their medicinal efficacy.

The purging saline waters are of two kinds: some owe their activity to sulphate of magnesia, others to sulphate of soda.

α. *Bitter Purging Waters; Bitter Waters; Bitter-salt Waters.*—In these waters sulphate of magnesia predominates. The waters of Epsom and Scarborough[1] in England, and of Seidlitz, Saidschütz, and Püllna, on the continent, are of this kind. Some thermal waters, as those of Acqua del Pozzeto, near Pisa, contain sulphate of magnesia.

β. *Glauber-salt Waters.*—This name is given by some writers on mineral waters to those waters which owe their purgative qualities to sulphate of soda.

Some of these are warm, and possess alkaline qualities; and they are therefore called the *warm alkaline glauber-salt waters.* To this division belong the Carlsbad[2] waters.

Some are cold and alkaline, and are termed *cold alkaline glauber-salt waters;* as those of Marienbad (the Kreuzbrunnen and Ferdinandsbrunnen) and Franzensbrunn (the Salzquelle).

Some are devoid of alkaline properties, but contain, besides sulphate of soda, various earthy and alkaline salts. They are the *earthy glauber-salt waters.* To this division belong the springs of Cheltenham,[3] Leamington,[4] and Spital.

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[1] See Dr. Short's *Natural, Experimental, and Medicinal History of the Mineral Waters of Derbyshire, Lincolnshire, and Yorkshire, particularly of Scarborough,* London, 1734.

[2] See Kreysig, *On the Internal Use of the Mineral Waters of Carlsbad, Marienbad, Ems,* &c. Translated by Thomson. 1824.

[3] See Dr. Scudamore on Cheltenham Waters, in his work on Mineral Waters, before quoted.—Also Maccabe's *Treatise on the Cheltenham Waters,* London.

[4] See Dr. Lambe's Analysis, in the *Manchester Memoirs,* vol. v.—Also Dr. Scudamore's work before quoted; and Dr. Loudon's *Practical Dissertation on the Waters of Leamington Spa.* 1828.

In full doses, the waters of this order are mild cathartics. In small and repeated doses they act as refrigerants and alteratives. They are useful in diseased liver, dropsical complaints, habitual constipation, hemorrhoids, determination of blood to the head, &c.

Order 2. Salt or Brine Waters.—The characteristic ingredient of these waters is chloride of sodium. Iodine or bromine, or both, have been recognised in some of them, and doubtless contribute somewhat to the medicinal effects.

Those salt waters whose chief ingredient is chloride of sodium, with which they are largely impregnated, are called *brine springs*. In England, the principal are Middlewich and Nantwich in Cheshire, Shirleywich in Staffordshire, and Droitwich in Worcestershire. The springs of Ashby-de-la-Zouch, in Leicestershire, contain, besides a large quantity of common salt, a considerable quantity of chloride of calcium. The Kreuznach and Salzhausen springs in Germany may be referred to this division.

In the *saline thermal springs* chloride of sodium is the chief constituent, but it is associated with various other alkaline and earthy salts. The waters of Wiesbaden, Baden-Baden, and Bourbonne, are of this kind.

In some of the *saline cold springs* chloride of sodium is the leading ingredient, but associated with other salts; as the waters of the Cheltenham Old Well, of Leamington, and the salt spring at Pyrmont.

Some of the salt springs contain iron, and are in consequence called the *chalybeate salt springs;* as those of Kissingen (Ragozzibrunnen) and Homburg.

Bromine or iodine, or both, have been detected in the state of bromide and iodide in several of the salt springs, which, in consequence, have been denominated *bromine and iodine salt springs*. The English brine springs before mentioned, the Woodhall or Iodine Spa[1] near Horncastle in Leicestershire, and the Kreuznach brine springs, are of this kind.

Taken in large quantities, saline or brine waters are emetic and purgative. In small but continued doses they act as alteratives, and are supposed to stimulate the absorbent system. They have been principally celebrated in glandular enlargements, especially those which are of a scrofulous nature.

The water of the Dead Sea belongs to this order (see *ante*, p. 292).

Order 3. Calcareous Waters.—Those saline mineral springs whose predominating constituent is either sulphate or carbonate of lime, or both, are denominated calcareous waters.

The Bath, Bristol, and Buxton thermal waters are of this kind.

When taken internally, their usual effects are stimulant (both to the circulation and the urinary and cutaneous secretions), alterative, and constipating; and are referable, in part, to the temperature of the water, in part to the saline constituents. Employed as baths, they are probably not much superior to common water heated to the proper temperature; but they have been much celebrated in the cure of rheumatism, chronic skin diseases, &c.

Bath water[2] is generally employed, both as a bath and as an internal medicine, in various chronic diseases admitting of, or requiring, the use of a gentle but continued stimulus; as chlorosis, hepatic affections, gout, rheumatism, lepra, &c. Diabetes has appeared to be benefited by it.

Buxton water, taken internally, has been found serviceable in disordered conditions of the digestive organs, consequent on high indulgence and intemperance; in calculous complaints; and in gout: employed externally, it has been principally celebrated in rheumatism.[3]

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[1] See Granville's *Spas of England*, vol. ii. p. 104.

[2] For an account of the Bath waters, see Wm. Oliver, *A Practical Dissertation on Bath Waters*, Bath, 1716.

Dr. Sutherland, *Natural History, Analysis, and General Virtues of the Bath and Bristol Waters*, Lond. 1763.

Dr. Falconer, *A Practical Dissertation on the Medicinal Effects of the Bath Waters*, Bath, 1790.

Dr. Gibbes, *A Treatise on the Bath Waters*, 1800.—Another edition, 1812.

Dr. E. Barlow, *Essay on the Bath Waters*, Lond.

Mr. Spry, *A Practical Treatise on the Bath Waters*, Lond. 1822.

[3] On the Buxton Waters, see an anonymous *Treatise on the Nature and Virtues of Buxton Water*, Lond. 1761; Dr. G. Pearson's *Observations and Experiments for investigating the Chemical History of the Tepid Springs at Buxton*, London, 1784; Dr. James Denman's *Observations on the Effects of Buxton Water*, Lond. 1793; Mr. W. H. Robertson's *Medicinal Property of Buxton Water*, Lond.; and Sir Charles Scudamore's work, already quoted.

The water of Bristol Hot-well is taken in dyspeptic complaints and pulmonary consumption.[1]

Order 4. Alkaline Waters.—The mineral waters denominated alkaline, contain carbonate or bicarbonate of soda as their characteristic ingredient. The thermal springs of Teplitz[2] and Ems belong to this order. The waters of this order pass insensibly into, and are, therefore, closely related to, the waters of the preceding classes.

Springs which contain carbonate of soda, with a considerable excess of carbonic acid are denominated *acidulo-alkaline,* and have been already noticed among the *acidulous* or *carbonated waters* (see *ante,* p. 299). The Vichy waters belong to this division (see *ante,* p. 259). The Selters waters are called *acidulo-alkaline-muriatic,* on account of the common salt which they contain. The Carlsbad waters are also acidulo-alkaline, but on account of the sulphate of soda which they contain are called *warm alkaline glaubersalt waters* (see *ante,* p. 301). The *cold alkaline glaubersalt waters* before noticed (see *ante,* p. 301) are likewise acidulo-alkaline.

Those in which carbonate of soda is associated with protocarbonate of iron and excess of carbonate acid, have been referred to under the head of *acidulous carbonated chalybeates,* (see *ante,* p. 297).

The only mineral waters in this country which contain carbonate of soda,[3] are those of Malvern,[4] in Worcestershire; and Ilkeston, in Derbyshire, near Nottingham; but the quantity in both cases is very small. The first, which is a very pure water, contains only 0·61 parts of the carbonate in 10,000 of the water, and the second 3·355 grains in an imperial gallon. For external use, the alkaline waters are principally valuable on account of their detergent qualities. When taken internally, they act on the urinary organs. They may be employed in calculous complaints connected with lithic acid diathesis, in gout, in dyspepsia, &c.

Order 5. Siliceous Waters.—Most mineral waters contain traces of silica, but some contain it in such abundance that they have been denominated siliceous. Thus, in the boiling springs of Geyser and Reikum, in Iceland, it amounts to nearly one-half of all the solid constituents. In these waters the silica is associated with soda (silicate of soda), sulphate of soda, and chloride of sodium.[5] I am unacquainted with their action on the body. It is probably similar to that of the alkaline waters.

For the following table of the fixed constituents of some of the most celebrated mineral waters, I am indebted to Dr. Gairdner's work[6]:—

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[1] Consult Dr. Carrick's *Dissertation on the Chemical and Medical Properties of the British Hotwell Water,* Bristol, 1797.

[2] *Die Bäder von Teplitz,* von A. Reuss, Teplitz, 1835.

[3] The deep-well water of the London basin contains carbonate of soda (see *ante,* p. 290), but this is not included among mineral waters.

[4] For an account of the Malvern Waters, see Dr. J. Wall's *Experiments and Observations on the Malvern Waters,* Worcester, 1763; Dr. M. Wall's *Malvern Waters,* Oxford, 1806; and Mr. Addison's *Dissertation on the Nature and Properties of Malvern Water,* Lond. 1828.

[5] See Dr. Black's analysis, in the *Trans. of the Roy. Soc. of Edinb.* vol. iii.; also, Faraday's, in Barrow's *Visit to Iceland.*

[6] *Essay on the Natural History, Origin, Composition, and Medicinal Effects of Mineral and Thermal Springs,* London, 1832.

FIXED CONSTITUENTS
ENTERING INTO THE COMPOSITION OF SOME OF THE MORE CELEBRATED
MINERAL SPRINGS.

Proportions in 10,000 *parts of Water.*

Note.—In reducing the analyses contained in this Table to a uniform measure, in order to render them susceptible of direct comparison with each other, I have assumed the old English gallon as = 58,338 grains; the wine pint = 7305 grs.; the imperial gallon = 70,000 grs.; and the German 16-ounce measure = 7368 grs.

The different salts have been reduced to their elementary constituents by Wollaston's scale of chemical equivalents.

THERMAL.

Name.	Country.	Acids.			Bases.			Oxide of Iron.	Silica.	Sum.	Authority and Date.	Remarks.
		Carbonic.	Sulphuric.	Muriatic.	Soda.	Lime.	Magnesia.					
San Restituta	Ischia....	..	19·30	29·05	34·50	2·08	2·35	3·19	0·40	94·44	Giudice	Iron in the state of ferruginous alumina; sub-borate of soda, 2·79.
Gurgitello..............	Ditto	14·55	9·05	11·18	31·45	2·95	2·38	1·39	0·56	74·03	Ditto	Iron as in San Restituta.
Wiesbaden	Nassau ..	1·38	0·87	33·09	31·99	5·29	0·92	0·05	0·26	57·63	Kastner, 1823..	Free carbonic acid, 18·9; azote; potash, 0·83; alumina, 0·56; organic extract, 2·37.
Carlsbad Sprudel	Bohemia .	7·45	14·50	6·40	24·55	1·75	0·85	0·02	0·75	54·59	Berzelius, 1822	Minute traces of phosphoric and fluoric acids, strontian, alumina, and manganese.
St. Nectaire............	France ..	15·13	0·87	13·00	23·90	2·45	1·14	0·14	1·00	53 94	Berthier.	
Vichy..................	Ditto	15·81	1·55	0 72	24·47	0·27	..	0·01	..	42·75	Ditto.	
Ems (Kränchesquelle) ..	Nassau ..	20·32	0·76	2·43	14 87	2·65	1·45	0·65	trace	42·74	Kastner, 1830..	Alumina, a trace; oxide of manganese, 2·42.
Olmitello	Ischia....	..	6·91	5·95	5·98	..	1·80	..	0·42	24·43	Giudice	Potash, 2·73.
Bath (King's Bath)	England..	2·38	8·71	..	2·79	5·29	0·77	0·03	0·27	20·53	R. Phillips......	The magnesia by Scudamore.
Mount d'Or............	France ..	2·86	0·36	2·05	4·74	0·90	0·28	0·10	2·10	13·39	Berthier.	
Geyser	Iceland ..	..	0·81	1·32	2·74	..	..	..	5·40	10·75	Black, 1791	Alumina, 0·48.
Chaudes Aigues	France ..	3·07	..	0·86	3·12	1.01	0·59	0·15	1·16	9·96	Berthier.	
Rycum (Reikum)	Iceland ..	..	0·71	1·55	2·43	..	..	..	3·73	8·47	Black, 1791	Alumina, 0·05.
Bristol Hot Well........	England..	1·02	2·25	1·17	1·17	0·82	0·43	..	..	8·19	Carrick, 1797 ..	Free carbonic acid, 12·99.
Schlangenbad	Nassau ..	3·50	..	0·80	2·42	0·90	0·53	..	..	6·96	Kastner, 1823 ..	Free carbonic acid, 6·0.
Teplitz	Bohemia .	1·89	0·40	0·29	2·62	0·36	0·18	0·03	0·42	6·24	Berzelius, 1822..	Phosphoric acid, potash, alumina.
Buxton	England..	0·78	0·06	0·28	0·19	1·04	0·04	..	..	2·70	Scudamore, 1820	Azote, 2·01, by Pearson.

COLD.

Vicar's Bridge	Scotland	..	203·00	0·18	0·16	2·56	13·2	103·00	..	563·10	Connell, 1831	Potash, a trace.
Püllnas	Bohemia	4·63	182·83	17·20	75·00	20·38	45·45	..	0·24	341·1	Struve	Potash, 3·55.
Saidschutz	Ditto	4·81	97·43	1·43	14·20	6·02	41·92	trace	0·16	177·4	Ditto	Nitric acid, 7·75; phosphoric acid; potash, 3·61; strontian, 0·03; alumina; oxide of manganese.
Leamington (Royal Pump)	England	..	20·80	71·90	57·90	12·00	4·95	1.09	..	153·9	Thomson, 1830	Traces of iodine and bromine, by Daubeny.
Harrowgate (old sulphur well)	Ditto	1·20	0·80	76·83	60·50	4·47	1·94	..	..	145·4	Scudamore, 1819.	
Airthrey (first spring)	Scotland	..	4·25	76·46	32·10	32·50	0·31	..	..	127·4	Thomson, 1828.	
Cheltenham (old well)	England	..	11·05	50·65	45·80	4·26	1·22	trace	..	111·6	Scudamore, 1819	Traces of iodine, by Daubeny.
Hartfell aluminous chalybeate	Scotland	..	63·23	..	..	..	..	40·00	..	101·3	Thomson, 1828	Alumina, 5·10.
Isle of Wight	England	..	48·58	2·95	6·85	5·68	0·82	14·60	0·96	88·21	Marcet	Alumina, 7·77.
Marienbad (Ferdinandsquelle)	Bohemia	9·52	27·60	9·50	38·05	2·87	1·67	0·12	0·50	86·18	Steinmann, 1820	Phosphoric acid, lithion, strontian, alumina, manganese, by Berzelius.
Dunblane (north spring)	Scotland	0·30	2.23	33·55	15·30	14·04	..	0·23	..	63·21	Murray, 1814.	
Vals	France	22·48	0·29	3·00	33·34	1·60	0·22	0·06	0·45	61·17	Berthier.	
Bilin	Bohemia	20·51	3·40	1·44	28·47	2·47	1·60	0·10	..	57·46	Reuss, 1788.	
Franzensbad (Franzensbrunn)	Ditto	5·44	18·50	6·21	26·70	1·26	..	0·37	0·48	55·80	Tromsdorff, 1820	Phosphoric acid, lithion, strontian, alumina, manganese, by Berzelius.
Pitcaithly	Scotland	0·30	0·73	27·20	8·50	13·99	..	trace	trace	46·95	Murray, 1814.	
Roisdorf	Rhenish Prussia	6·76	2·50	9·70	16·00	1·78	1.33	0·07	0·21	38·11	Bischoff, 1826	Potash.
Epsom	England	2·50	14·80	4·21	5·64	11·80	..	..	..	37·94	Daubeny, 1830	Trace of bromine.
Selters (Nieder)	Nassau	5·37	0·18	9·92	16·06	1·37	1·00	0·12	0·38	34·60	Bischoff, 1826	Phosphoric acid, 0·19.
Fachingen	Ditto	11·49	0·12	2·63	15·63	1·83	1·09	0·07	0·11	32·98	Ditto	Phosphoric acid, 0·005.
Soden	Ditto	3·35	0·07	12·30	10·72	4·08	0·06	0·08	0·06	30·89	Meyer, 1820.	
Moffat	Scotland	..	2·80	13·60	12·75	0·68	0·26	..	..	30·03	Thomson, 1828.	
Pyrmont	Germany	4·03	9·83	0·99	1·29	85·6	1·98	0·36	0·68	27·89	Struve	Phosphoric acid, potash, strontian, manganese.
Marienfels	Nassau	4·83	0·18	1·88	3·42	2·20	1·27	0·10	trace	15·99	Kastner	Potash, 1·19; strontian; manganese; phosphoric acid.
Strathpeffer (pump-room)	Scotland	..	9·32	2·17	6·18	2·33	0·30	..	..	15·36	Thomson, 1828	Potash?
Geilnau	Nassau	6·00	0·07	0·18	5·08	1·46	1·40	0·13	0·14	14·66	Bischoff, 1826	Phosphoric acid, 0·19.
Weilbach	Ditto	3·61	0·81	1·31	4·60	1·55	2·05	..	..	14·40	Creve, 1810	Sulphur-resin, 0·48.
Hartfell Spa	Scotland	..	2·76	3·05	..	2·30	..	2·49	..	9·95	Thomson, 1828	Alumina, a trace.
Langenschwalbach Weinbrunn	Nassau	3·84	0·12	0·12	0·34	1·55	1.95	0·67	trace	8·58	Kastner, 1829	Potash, lithion, iodine, strontian, alumina, manganese, phosphoric acid.
Spa	Belgium	6·63	0·51	0·33	0·92	0·74	0·72	7·90	0·68	5·92	Struve	Phosphoric acid; potash, 0·58; manganese.
Carlsbad (Sauerling)	Bohemia	0·28	0·13	0·07	0·28	0·16	0·06	0·06	0·61	1·42	Berzelius, 1822	Phosphoric acid, fluate of lime, alumina, oxide of manganese.
Tunbridge	England	0·20	0·14	0·29	0·19	0·39	0·02	0·38	0·07	1·32	Scudamore, 1816	Oxide of manganese.
Malvern	Ditto	0·32	0·14	0·08	0·55	0·03	0·02	0·04	..	1·01	Phillip, 1805.	

For further details respecting mineral waters in general, the reader is referred to the following works:—

Dr. J. Rutty—*Methodical Synopsis of Mineral Waters*, Lond. 1757.

Dr. D. Munro—*Treatise on Mineral Waters*, Lond. 1770.

Dr. W. Saunders—*Treatise on the Chemical History and Medical Powers of some of the most celebrated Mineral Waters*, Lond. 1800.

G. F. L. Fuchs—*Systematische Beschreibung aller Gesundbrunnen und Bäder der bekannten Länder, vorzüglich Deutschlands, sowohl nach ihrer physisch-chemischen Beschaffenheit.* 2 Bd. Jena, 1801.

C. F. Mosch—*Die Bäder und Heilbrunnen Deutschlands und der Schweiz*, Leipzig, 1819.

Alibert—*Précis historique sur les Eaux Minérales*, Paris, 1826; also in his *Nouveaux Elémens de Thérapeutique*, 3me tom. 5me éd. Paris, 1826.

C. Stucke—*Abhandlung von den Mineralquellen in Allgemeinen, und Versuch einer Zusammenstellung von* 880 *der bekannteren Mineralquellen und Salinen Deutschlands, der Schweitz und einiger angrenzender Länder, mit analytischen Tabellen, worin etwa* 250 *chemische Analysen von Mineralquellen angegeben sind.* Nebst 1, Charte von Deutschlands Mineralquellen. Cöln. 1831.

E. Osann—*Physikalisch-medicinische Darstellung der bekannten Heilquellen der vorzüglichsten Länder Europa's*, Berlin, 1er Theil, 1829.—2er Theil, 1832.—2te Aufl. 1839.

L. F. v. Zedlitz—*Balneographisch-statist-histor. Hand- und Wörterbuch, oder die Heilquellen und Gesundbrunnen Deutschlands*, &c. Leipzig, 1834.

Sir C. Scudamore—*On the Properties of the Mineral Waters of England*, 8vo. 2d edit. 1833.

Dr. T. Thomson—*Cyclopædia of Practical Medicine*, art. *Waters, Mineral*, vol. iv. Lond. 1835.

Mr. Lee—*An Account of the most frequented Watering Places on the Continent*, Lond. 1836.

Patissier et Bourtron-Charlard—*Manuel des Eaux Minérales Naturelles*, 2nde édit. Paris, 1837.

Dr. A. B. Granville—*The Spas of Germany*, Lond. 1837.—2d edit. 1838.

G. W. Schwartze—*Allgemeine und specielle Heilquellenlehre*, Leipzig, 1839.

A. Vetter—*Theoretisch-praktisches Handbuch der Heilquellenlehre.* Berl. 1839, 2te Ausg. 1845.

J. F. Simon—*Die Heilquellen Europas, mit vorzügl. Berücksichtig. ihrer chem. Zuzammensetzung nach ihrem physical. u. Med. Verhalten dargestellt.* Berlin, 1839.

H. C. W. Hufeland—*Prakt. Uebersicht der vorzügl. Heilquellen. Teutschlands nach eigenen Erfahrungen.* Herausg. u. ergänzt von E. Osann. 4 Aufl. Berlin, 1840.

Mr. Lee—*Principal Baths of Germany*, 1840.

Dr. J. Johnson—*Pilgrimage to the Spas*, Lond. 1841.

Dr. A. B. Granville—*The Spas of England*, Northern, Midland, and Southern, 1841.

Sir A. Downie—*On the Efficacy of Mineral Waters in the Cure of Chronic Complaints*, 12mo. 1841.

ARTIFICIAL MINERAL WATERS.—In this country the demand for artificial mineral waters is extremely limited, and I do not, therefore, think it necessary to enter into any details respecting their manufacture; but shall content myself with referring those interested in the matter to the works of Soubeiran[1] and Guibourt[2] for full details.[3]

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[1] *Nouveau Traité de Pharmacie*, t. ii. 2nde édit. Paris, 1840.

[2] *Pharmacopée Raisonnée, ou Traité de Pharmacie pratique et theorique*, par N. E. Henry et G. Guibourt, 3me édit. revue et considérablement augmentée par N. J. B. G. Guibourt. Paris, 1841. The *Codex Pharmacopée Française* also contains formulæ for the preparation of artificial mineral waters.

[3] The manufacture of *Sodaic* and *Magnesian Waters* will be described hereafter.

4. Hydrogenii Binoxydum.—Binoxide of Hydrogen.

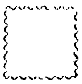
Formula HO^2. *Equivalent Weight* 17.

Peroxide of Hydrogen; Oxygenated Water.—Discovered by Thenard in 1818. Its medicinal qualities are at present unknown; but, from its remarkable chemical properties, some persons have imagined that it must be a powerful therapeutic agent. The Dutch Society of Sciences at Haarlem offered a prize in 1830 for an essay on its chemical and medicinal properties, but I am not aware that the adjudication has taken place. Thenard ascertained that fibrine and the animal tissues decompose the binoxide with the evolution of oxygen. It whitens the epidermis and the epithelium of the tongue, causing a pricking sensation, and it thickens the saliva. It must not be confounded with either *aqua oxygenii* (see *ante*, p. 271) or the *aqua nitrogenii protoxydi*.

OZONE.—The term ozone (from *ὄζω, I smell*) has been applied by Schönbein to an hypothetical substance supposed to be the cause of the odour evolved by the electric machine. Schönbein[1] considers it to be a binoxide of hydrogen isomeric but not identical with Thenard's binoxide. Berzelius regards it as oxygen in an allatropic condition.[2] Schönbein describes its effects on the lungs as similar to those of chlorine and bromine. He says that a mouse was killed in five minutes by it, and that he himself was seriously affected by breathing an atmosphere charged with it.

ORDER III. CARBON AND CARBONIC ACID.

5. CARBONIUM.—CARBON.

Symbol C. *Equivalent Weight* 6. *Equivalent Volume of Carbon Vapour* (?) 1 or 

HISTORY.—The term *carbon* (from *carbo, ōnis*, coal) was first employed by Morveau, Lavoisier, and Berthollet, to designate the pure matter of charcoal. To the second of these chemists we are indebted for demonstrating, that by combustion in oxygen gas the diamond and charcoal yield the same product—namely, carbonic acid gas.

NATURAL HISTORY.—Carbon is found in both kingdoms of nature:

α. IN THE INORGANISED KINGDOM.—When pure and crystallized, it constitutes the diamond, which Sir D. Brewster[3] suspects to be of vegetable origin; but a specimen, described by Mr. Heuland,[4] was found in a primary rock. Plumbago and anthracite consist principally of carbon. The bituminous substances (as coal, petroleum, naphtha, &c.) also contain it. These are admitted by geologists to be of vegetable origin. Carburetted hydrogen is evolved from coal strata, marshy places, stagnant waters, &c. Carbonic acid is found either in the free state, as in the atmosphere, in mineral waters evolved from the earth in old volcanic countries, &c., or combined with metallic oxides, in the form of the carbonate of lime, iron, &c. It is remarkable that carbon is rare among the older rocks.[5]

β. IN THE ORGANISED KINGDOM.—Carbon is an essential constituent of all organised beings, both vegetable and animal.

PROPERTIES.—Carbon is a solid, odourless, tasteless substance, neither fusible (?) nor volatile; combustible in oxygen gas, and yielding carbonic acid gas.

The other properties of carbon are so varied, that chemists are obliged to admit distinct varieties of this substance: the principal are the *diamond*,

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[1] *Pharmaceutical Journal*, vol. v. p. 139.

[2] Graham's *Elements of Chemistry*, 2d edit. p. 304.

[3] *Edinb. Philosophical Journal*, vol. iii. p. 98; and *Philosophical Magazine*, vol. i. p. 147, 1827.

[4] *Geological Transactions*, 2d series, i. 419.

[5] De la Beche, *Researches in Theoretical Geology*, p. 32, Lond. 1834.

plumbago, and *charcoal* (animal and vegetable). Of these, the two latter only require consideration in this work.

1. Plumbago vel Graphites.—Graphite or Black Lead.

HISTORY.—Plumbago (so called from its resemblance to *plumbum*, or lead), or graphite (from *γράφω, I write,* on account of its use as a writing material), was probably known to the ancients; but it was first accurately distinguished from other bodies with which it had been previously confounded, especially with molybdena (*bisulphide of molybdenum*), by Scheele,[1] in 1779.

The terms *plumbago, plumbum nigrum,* and *molybdæna,* met with in Pliny,[2] do not apply to graphite.

NATURAL HISTORY.—It is found in various parts of the world; chiefly in primitive rocks and the coal formations. It occurs at Borrowdale in Cumberland, in various parts of the continent of Europe (Bavaria, Bohemia, Spain, &c.), in Ceylon, and in the United States of America. A very pure graphite is found near Bustletown in Pennsylvania.

Graphite is found either crystallized or compact. Crystallized graphite (*graphites crystallinus*) may be foliated, scaly, or radiated: its forms are thin six-sided tables belonging to the rhombohedric system. Compact graphite (*graphites solidus*) occurs either massive or disseminated.

Borrowdale plumbago is of fine quality. It is brought to London, and sold by auction at a public-house in Essex-street, Strand, on the first Monday in every month.[3] The best quality usually sells for two guineas or more per pound, and is employed for making pencils.

Spanish plumbago is imported from Malaga. It is probably obtained from the mountain of Mora, near Marbella, in Andalusia. It is sometimes of superior quality.

Ceylon or *East India plumbago* is another sort which is extensively imported. Its quality is inferior.

German plumbago is imported from Hamburgh. It is of inferior quality, and is said to be the produce of Bohemia. The so-called *Mexican black lead* is imported from Hamburgh.

PROPERTIES.—As found in commerce, it is usually in kidney-shaped masses. Its colour is iron or steel-grey, with a metallic lustre. It has a greasy feel, and writes easily on paper. Its specific gravity is 2·08 to 2·45.

Characteristics.—It is known to be carbon by its yielding carbonic acid by combustion in oxygen gas. When burned, it usually leaves a residuum of silica and red oxide of iron. It is infusible before the blow-pipe. Its physical properties distinguish it from most other varieties of carbon. Some kinds of coal-gas charcoal (*artificial graphite*) closely resemble it. Of non-carbonaceous substances, molybdena (*bisulphide of molybdenum*) is the only substance that can be confounded with it in external appearance.

PURITY.—Graphite usually contains traces of iron and silica. When of good quality it is free from all visible impurities (sand, stones, &c.) When heated before the blow-pipe, it should be infusible, and not evolve any odorous vapour or smoke: its freedom from metallic sulphurets (as of antimony and lead) is thereby shown. It is insoluble in alkalies and acids. Hydrochloric acid boiled with it should dissolve only some minute portions of iron; and the filtered acid liquor should yield no precipitate on the addition of carbonate of ammonia, and no change of colour when sulphuretted hydrogen is added to it.

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[1] *Essays*, p. 246.

[2] *Historia Naturalis*, lib. xxxiv. cap. 47, 50, and 53, ed. Valp.

[3] *London Medical Gazette*, vol. xviii. p. 267.

The powder sold in the shops under the name of *black lead,* for polishing iron grates &c. is an adulterated article, and is unfit for medicinal purposes. It is usually prepared by reducing the quality of the so-called Mexican plumbago (German plumbago) by grinding it with sand, old black lead crucibles, a substance called Bideford black (which I am informed is a kind of black clay found near Bideford in Devonshire), and an inferior plumbago called common lead, seconds, or German gunpowder (from its being granulated like gunpowder). When reduced, it forms *Naples lustre, Mexican jet, black lead,* &c. Wackenroder[1] has signalised the existence of a commercial graphite, of which three-fourths were sulphuret of antimony.

For ordinary purposes, powdered graphite is purified by boiling it with nitro-muriatic acid, and then washing and drying it.

Dumas and Stas[2] purified it for analysis by heating it to redness with caustic potash, then washing it with water, boiling with nitric acid and nitro-muriatic acid to extract iron and bases, washing, drying, and then exposing it, at a white heat, to a stream of dry chlorine gas, by which chloride of iron and chloride of silicon were volatilized. When thus purified, it contained merely a trace of silica.

COMPOSITION.—It consists essentially of carbon, but is usually mixed with variable proportions of silica, iron, and other substances. The following are analyses of three varieties by Vanuxem[3]:—

	Borrowdale (*pure*).	*Borrowdale* (*impure*).	*Bustletown* (*pure*).
Carbon	88·37	61·27	95·4
Water	1·23	5·33	0·6
Silica	5·10	10·10	2·6
Alumina	1·00	3·20	0·0
Oxides of Iron, Manganese, &c.	3·60	20·00	1·4
Plumbago	99·30	99·90	100·0

I suspect, however, that the finest varieties of the Borrowdale graphite contain a less quantity of foreign matter than is here stated. Graphite has been recently analysed by Dr. R. F. Marchand,[4] who states that 1·4580 *gramme* of native graphite left a residue of pure white silica, without a trace of oxide of iron, weighing only 0·0075.

On the erroneous supposition that the carbon was chemically combined with iron, graphite was formerly called *carburet* or *percarburet of iron.* From some observations of Schrader, however, it would appear that the iron is in combination with titanic acid.

PHYSIOLOGICAL EFFECTS.—Various properties have been assigned to it; but further evidence is wanting to establish its action on the body. Richter[5] says it alters, in some way, the lymphatic secretion and the condition of the skin; and, after some days' use, causes increased secretion of urine, with difficulty in passing it.

USES.—It has been employed both externally and internally in chronic diseases of the skin (as herpes). When used externally, it is employed in the form of ointment (*Unguentum plumbaginis*), composed of from one to six drachms of plumbago to an ounce of lard. Internally the dose is ten or twelve grains to a drachm, or more.

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[1] *Pharmaceutisches Central Blatt für* 1838, p. 524.

[2] *Ann. Chim. et. Physiq.* 3me sér. i. p. 1-54.

[3] Silliman's *Journal*, vol. x. p. 105.

[4] *Proceedings of the Chemical Society*, No. i. p. 12, 1841.

[5] *Ausführliche Arzneimittellehre*, 3er Bd. p. 486, Berlin, 1828.

2. Carbo Ligni.—Wood Charcoal.

HISTORY.—Wood charcoal must have been familiar to man from the most remote period of antiquity, and was probably known to the first inhabitants of the globe. For an account of the ancient method of procuring it, I must refer the reader to the works of Theophrastus (cap. x.) and Pliny.[1]

NATURAL HISTORY.—Wood charcoal is always an artificial product. Some samples of Bovey coal have very much the appearance of wood charcoal, but are readily distinguished by their containing hydrogen, in consequence of which they burn with a yellow flame. Moreover, they are not good conductors of galvanic electricity.[2]

PREPARATION.—Ordinary wood charcoal is prepared, on the large scale, for the purposes of fuel, by burning billet-wood (oak, beech, hazel, and sometimes willow), piled in a conical heap, covered with turf and sand, to prevent the access of atmospheric air, a few holes being left near the bottom and one at the top, to occasion a draught. The heap is then set fire to, and when the flame has pervaded the whole mass, the holes are closed. When cooled, the billets are found converted into charcoal. For an account of the mode of arranging the wood in heaps, consult Dumas.[3]

The charcoal used in the manufacture of gunpowder is prepared by the distillation of wood in cast iron cylinders, set horizontally (or nearly so) in brickwork, over a furnace. The charge is introduced at the front, and the opening is then perfectly secured by an iron door and bar, well luted. The back part of each cylinder is perforated by two pipes, one above the other, which bend downwards into tubs containing water. The tar flows out by the lower pipe, and the pyroligneous acid by the upper one, and condenses in the receiver (the tub). The smoke and vapours escape into the air. When sufficiently burnt, the charcoal is raked out into iron boxes, which are immediately covered, to exclude the air.[4] At the Waltham Abbey mills, charcoal is prepared from the Dogwood (*Cornus sanguinea*) the Alder (*Alnus glutinosa*), and the Willow (*Salix*). The Dogwood charcoal (which occasions a peculiar ringing sound when it falls on stones) is used for rifle powder: the other kinds for cannon and musket powder. Lieut.-Col. Moody tells me that the Dutch White Willow (*Salix Russelliana?*) is the best kind of willow for charcoal, but that the Huntingdon Willow is also a good one. (See *Acidum aceticum.*)

Box wood charcoal for galvanic purposes is prepared by putting prismatic pieces of box wood, about an inch long and half an inch thick, into a crucible, covering them with dry sand, and exposing them to a red heat for about an hour.

PROPERTIES.—Wood charcoal is black, odourless, and insipid. It has the texture of the wood from which it has been obtained. It is brittle, and may be easily pulverized, especially when hot. Though a very bad conductor of heat, it is an excellent conductor of electricity. It is insoluble, infusible, and incapable of volatilization. Its specific gravity varies according to the substance from which it has been obtained. A remarkable property possessed by it is that of abstracting certain substances (such as hydrosulphuric acid, organic colouring principles, various odorous matters, &c.) from liquids in which they are dissolved, or through which they are diffused. Another curious quality is that of condensing, within its pores, a certain quantity of any gas with which it may be placed in contact. Thus one volume of boxwood charcoal absorbs 1·75 volumes only of hydrogen gas, but 90 volumes of ammoniacal gas. Some of the properties now mentioned (as that of decolorizing) are possessed, in a more eminent degree, by animal charcoal.

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[1] *Hist. Nat.* lib. xvi. cap. vii.

[2] Kidd's *Outlines of Mineralogy*, vol. ii. p. 47.

[3] *Traité de Chimie appliqué aux Arts*, t. i. p. 561.

[4] For some further details, consult Mr. Wilkinson's work on the *Engines of War*, Lond. 1841.

Characteristics.—By combustion in oxygen gas, wood charcoal yields carbonic acid gas; a property by which it is shown to consist of carbon. Its texture and appearance, as well as the nature of the ashes which it leaves behind when burnt, serve to distinguish it from other forms of carbon. (See *animal* charcoal).

COMPOSITION.—The following is the composition of charcoal obtained from different woods, according to the experiments of Berthier[1]:—

	Poplar.	Maple.	Ash.	Fir.	Alder.	Birch.	Oak.	Hazel.
Carbon	85·6	85·2	83·2	90·3	90·2	88·1	88·0	87·7
Calcined Ashes	1·0	1·0	1·8	2·2	1·8	1·9	2·0	2·0
Volatile Matters ...	13·4	13·8	15·0	7·5	8·0	10·0	10·0	10·3
Charcoal	100·0	100·0	100·0	100·0	100·0	100·0	100·0	100·0

Wood ashes consist of soluble alkaline salts and of insoluble matters. The alkaline salts have for their base potassium and sodium: they contain (or yield) carbonic, sulphuric, and hydrochloric acids, a little silica, and sometimes a trace of phosphoric acid. The insoluble matters contain carbonic and phosphoric acids, silica, lime, magnesia, and the oxides of iron and manganese. The quantity of carbonic acid is never sufficient to saturate both the alkalies and the earths, in consequence of the heat having expelled carbonic acid from the earthy carbonates. (See *Potassæ carbonas.*)

PHYSIOLOGICAL EFFECTS.—Wood charcoal I believe to be an inert substance both with respect to animals and vegetables. Burdin[2] gave a pound of it daily without producing any other effect than that of blackening the stools. A variety of properties and virtues have, however, been ascribed to it, as I believe, without foundation: thus it has been termed anodyne, emmenagogue, tonic, purgative, &c. In the French edition of Hahnemann's Materia Medica,[3] no less than thirty-five pages are occupied with the enumeration of the symptoms produced by one-millionth of a grain of this substance!!

USES.—In this country, charcoal is used as a therapeutic agent, principally as a disinfectant and antiseptic, to absorb the fetid odour evolved by gangrenous and phagedenic ulcers. For this purpose it may be used in the form of powder or of poultice. Its disinfecting and antiseptic powers, however, are much inferior to those of chlorine, or of the chlorides [hypochlorites] of lime and soda.

As a *tooth-powder* it is a valuable agent, freeing the teeth from the foreign matters which cover them, and at the same time counteracting the unpleasant smell of the breath arising from decayed teeth or disordered stomach; but it is apt to lodge in the space between the gum and tooth, forming an unsightly livid circle (see *ante*, p. 155.) Brachet[4] states, that it checks caries of the teeth. *Areca-nut charcoal* is a favourite variety for tooth-powders. Its fancied superiority is ascribed to the extreme hardness of its particles.

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[1] *Traité des Essais par la voie sèche*, t. i. p. 286, Paris, 1834.

[2] *Dict. de Mat. Méd.* art. *Carbone*, t. ii. par MM. Mérat and De Lens.

[3] *Traité de Matière Médicale*, par S. Hahnemann; traduite par A. J. L. Jourdan, Paris, 1834.

[4] *Considérations sur l'Usage du Carbone en Médecine*, Paris, 1803.

Internally, charcoal has been exhibited in various affections of the alimentary canal, such as dyspepsia, cardialgia, diarrhœa, and dysentery. The beneficial effects said to have been produced in these cases can only be referred to the action of charcoal on the secretions of the bowels; an explanation apparently supported by Dr. Chapman's statement, that in dysentery, when the stools are highly acrid and offensive, charcoal entirely divests them of their bad smell and acrimony. In consequence of the advantage said to have been obtained by Dr. Calcagno, of Sicily, by the use of charcoal in intermittents, it was tried by Dr. Calvert, physician to the British forces at Palermo, and with success.[1] In this country, however, I believe it is never resorted to in ague by medical practitioners. Dr. Daniel, of Savannah, has recommended it in obstinate constipation, and in the nausea and confinement of the bowels which frequently attend pregnancy. It has also been used in various other diseases, but experience has not confirmed its efficacy.

ADMINISTRATION.—The dose of charcoal, as ordered by different writers, varies from ten grains to a tablespoonful or more.

CATAPLASMA CARBONIS LIGNI, D. *Charcoal Poultice.* (Prepared by taking Wood Charcoal red hot from the fire, extinguishing it by sprinkling dry sand over it, reducing it to a very fine powder, and adding it to the simple cataplasm warm).—The *simple cataplasm* here referred to is made by adding boiling water to a mixture of one part linseed meal and two parts oatmeal, and smearing it over with olive oil. The charcoal poultice is applied to foul, unhealthy, and gangrenous ulcers, to destroy their fetor and improve their appearance. As an antiseptic, however, it is inferior to the chlorides [hypochlorites] of lime and soda.

3. Carbo Animalis.—Animal Charcoal.

HISTORY.—This substance must have been known from the most ancient times. The kind usually met with in the shops is prepared from bones, and is termed *bone black* or *animal black.* It is sometimes sold as *ivory black* (*ebur ustum nigrum*).

PREPARATION.—Animal charcoal is extensively manufactured from bones for the use of sugar-refiners; and during the process an ammoniacal liquor (called *bone spirit*) is obtained as a secondary product. The operation is thus conducted.

Bones are first boiled to remove the fatty matter which is used in soap-making. The larger and finer pieces are then selected for the manufacture of buttons, handles of knives and tooth-brushes, &c.; while the smaller and refuse portions are sold as manure. The remainder is submitted to distillation.

The stills or retorts are sometimes made of cast iron, and in shape and size resemble those used at gas-works. Formerly they were placed horizontally in the furnace,[2] and the volatile matters were conveyed away by a pipe opening into the ends of the retorts. To facilitate the speedy removal of the charcoal, they are sometimes placed obliquely in the furnace: the bones are introduced at the upper end, and the charcoal is removed from the lower end;—while the volatile matters are conveyed away by a side pipe. But these retorts are considered inferior to the vertical ones, on account of the facility and speed with which the latter can be charged and discharged. The vertical stills or retorts are made either of cast iron or of Welch bricks; the latter, I am informed, are preferable. In a large manufactory of animal charcoal in this metropolis, the shape of the retort is that of a right rectangular prism; its height being twenty feet, its length about three feet, and its breadth two feet. It is closed at the top by a moveable iron plate, secured by a screw bolt. It is closed below by a double trapdoor opening underground. Around the retort is a furnace of brickwork, whose shape is that of a truncated pyramid.

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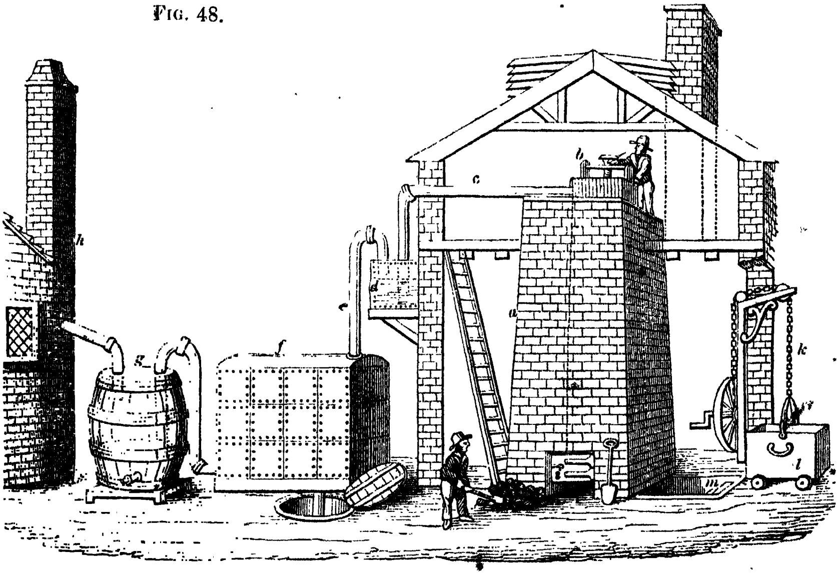
[1] *Edinb. Med. and Surg. Journ.* vol. x. p. 13.

[2] See Ure's *Dictionary of Arts and Manufactures*, p. 1081, figs. 954 and 955, Lond. 1839.

FIG. 48.



Manufactory of Animal Charcoal.

a. Furnace enclosing the retort.
b. Top of the retort.
c. Pipe to convey away the volatile products.
d. Water cistern, through which the volatile matter passes.
e. Pipe leading to
f. The iron receiver (an old steam boiler), communicating with a reservoir cistern under ground.
g. Second receiver.
h. Chimney into which the residual vapour passes.
i. Furnace door.
k. Crane.
l. Canister to receive the charcoal.
m. Steps leading to the lower end of the retort.

The bones are introduced at the upper end of the retort (*b*). The volatile products are conveyed away by the iron pipe (*c*). After passing through the cistern (*d*) they are conveyed to a series of receivers (*f* and *g*), where the brown ammoniacal liquor (*bone spirit*) and the empyreumatic oil (*animal oil*) are deposited. The non-condensible portion is a fetid inflammable gas: this, after passing through water contained in the second receiver, is conveyed into a chimney, or is burned. The solid residue in the retort is removed, while red hot, through the lower and underground end of the retort, into wrought-iron canisters (*l*), which are instantly closed by iron covers, luted to make them air-tight, and then raised to the surface by a crane (*k*). When cold it is ground, and sold as *animal, bone,* or *ivory black.*

The volatile products of this operation are easily accounted for. When bones are heated, their cartilaginous or gelatinous portion undergoes decomposition, and its elements enter into new combinations. Some of the oxygen and hydrogen unite to form *water.* Carbon and oxygen, combining in different proportions, furnish *carbonic oxide* and *acid.* Carbon with hydrogen forms *carbohydrogen;* while nitrogen uniting with hydrogen produces *ammonia,* which, with some carbonic acid, forms *carbonate of ammonia.* The *empyreumatic* or *animal oil* consists of carbon, hydrogen, and oxygen, with probably some nitrogen.

PROPERTIES.—In its general properties animal charcoal agrees with charcoal procured from wood. It is denser and less combustible than wood charcoal; but greatly exceeds the latter in its power of destroying colour and odour. In the crude state (*carbo animalis crudus*) it occurs in four forms in commerce: unground, and retaining the shape of the bones from which it was procured; coarsely ground (*grain animal charcoal*), as used by the sugar refiners; more finely ground (*coarse grit animal charcoal*), as used by distillers; and finely ground or pulverized (*fine animal charcoal*). In the latter state it is frequently damped and sold, at a lower price, as *ivory black* to the makers of blacking, &c.

Characteristics.—Animal charcoal yields, when burnt in oxygen gas or atmospheric air, carbonic acid like other forms of carbon. From vegetable charcoal it may be distinguished by its texture and appearance, as well as by the nature and properties of its ashes. To obtain the ashes for examination a portion of the charcoal should be burned on a red-hot iron into white ashes. Wood ashes dissolve in sulphuric acid and yield a bitterish solution: bone ashes are very sparingly affected by that acid, and form with it a compound having a very different taste.

COMPOSITION.—Animal charcoal, prepared by calcining the bones of the ox, sheep, and horse, consists of the following ingredients[1]:—

Phosphate of Lime Carbonate of Lime	88·0
Charcoal	10·0
Carburet or Silicet of Iron	2·0
Sulphuret of Calcium or Iron	traces
Common Bone Black	100·0

The proportion of charcoal here stated is certainly small. Dr. Christison states that he has found, in the animal black of this country, usually about 20 per cent. of charcoal. When bone black is calcined in the open air, the carbon is burnt off and a whitish residue is obtained called *bone ash.* (See *Calcis subphosphas.*)

For the ordinary purposes of the arts, as sugar refining, crude animal charcoal answers very well, because the earthy salts in no way affect the process. But in various pharmaceutical operations the presence of phosphate and carbonate of lime would preclude its use, on account of the free acid in the liquids to be decolorised. Hence the necessity of the purification of animal charcoal. (See *Carbo animalis purificatus,* p. 316.)

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[1] Dumas, *Traité de Chimie,* t. i. p. 450, Paris, 1828.

Animal charcoal, when deprived of its saline matters, usually contains traces of nitrogen. Döbereiner, indeed, supposed it to be a kind of subnitruret of carbon, composed of one equivalent or 14 parts of nitrogen, and six equivalents or 36 parts of carbon. Bussy, however, has shown, that though animal charcoal retains its nitrogen with considerable obstinacy, yet that the latter may be separated by heat.

PHYSIOLOGICAL EFFECTS.—The remarks already made in reference to the physiological effects of wood charcoal apply equally well to animal charcoal.

USES.—The principal use of animal charcoal is as a decolorising agent in various pharmaceutical processes, as in the refining of sugar, the preparation of disulphate of quina, hydrochlorate of morphia, veratria, &c. The superior value of animal to vegetable charcoal for this purpose is usually referred to the minute separation of the carbonaceous particles effected by the presence of other matters, as of phosphate of lime, when bones are employed. Carbonate of potash is better for this purpose than phosphate of lime. The property possessed by minute particles of charcoal, of abstracting colouring matter from liquids, depends, probably, on some chemical affinities existing between carbon and colouring matter. It has been stated that charcoal which has been once used cannot have its decolorising property restored by a fresh ignition, unless it be mixed with some inorganic substance. This, however, is an error. The animal charcoal which has been used in sugar refining, is returned to the maker to be fresh ignited, and is then employed again, and this process of re-igniting is repeated many times, without any loss of decolorising power.

The following table, drawn up by Bussy,[1] shews the decolorising power of charcoal for indigo and molasses. The indigo test liquor contained $\frac{1}{1000}$th of this substance; and, therefore, every gramme of the solution decolorised represents a millegramme (= 0·0154 troy gr.) of indigo absorbed by the charcoal. The molasses solution consisted of one part molasses and twenty parts of water.

Kind of Charcoal employed. (Weight always 1 gramme = 15·434 troy grains.	*Solution of Indigo decolorized.*	*Solution of Molasses decolorized.*	*Decolorizing power on Indigo.*	*Decolorizing power on Molasses.*
	grammes.	grammes.		
1. Bone charcoal	32	9	1·00	1·00
2. Vegetable or animal oil charred with phosphate of lime	64	17	2·00	1·90
3. Bone charcoal washed with hydrochloric acid	60	15	1·87	1·60
4. No. 3 calcined with potash	1450	180	45·00	20·00
5. Calcined lamp-black	128	30	4·00	3·30
6. No. 5 calcined with potash	550	90	15·20	10·60
7. Charcoal of carbonate of soda decomposed by phosphorus	380	80	12·00	8·80
8. Charcoal of acetate of potash	180	40	5·60	4·40
9. Starch charred with carbonate of potash	340	80	10·60	8·80
10. Albumen charred with potash	1080	140	34·00	15·50
11. Gelatine charred with potash	1150	140	36·00	15·50
12. Blood charred with phosphate of lime	380	90	12·00	10·00
13. Blood charred with chalk	570	100	18·00	11·00
14. Blood charred with potash	1000	180	50·00	20·00

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[1] *Journal de Pharmacie*, t. viii. p. 257, 1822.

The effect of animal charcoal in removing substances from their solutions is not limited to colouring matters: it also deprives liquids of their bitter principles, alkaloids, resins, tannin, and even some metallic salts.[1] It is obvious, therefore, that it cannot be employed to decolorize poisonous liquids, since it deprives the solution of more or less of its deleterious ingredient, as well as of its colouring matter. Moreover, it is clear that manufacturers who employ animal charcoal to decolorize their solutions must lose part of their product; and hence in the preparation of disulphate of quina, &c. a loss must be sustained by the employment of charcoal as a decolorizer.

Dr. Garrod[2] has recently proposed purified animal charcoal as a general antidote in cases of poisoning; but I agree with Mr. Taylor[3] in regarding the experiments adduced in favour of it as inconclusive. Like many other agents it is certainly capable of acting mechanically and of thereby impeding the action of poisons (see *ante*, pp. 154, 155, and 159), but beyond this there is no evidence of its antidotal power.

CARBO ANIMALIS PURIFICATUS, L. E. *Purified Animal Charcoal.* (Animal Charcoal, lbj.; Hydrochloric Acid [commercial, *E.*] and Water, of each f℥xij. Mix the acid with the water, and pour it gradually upon the charcoal; then digest for two days with a gentle heat, frequently shaking them. Set by, and pour off the supernatant liquor, then wash the charcoal very frequently with water, until nothing acid is perceptible; lastly, dry it. *L.*—The *Edinburgh College* directs the mixture to be boiled, after the digestion for two days; then dilute with two pints of water; the undissolved charcoal collected in a filter of linen and calico, and washed with water till what passes through scarcely precipitates with solution of carbonate of soda. The charcoal is to be heated first moderately, and then to redness in a closely covered crucible.)—In this process the hydrochloric acid dissolves the phosphate of lime, and decomposes the carbonate of lime and sulphuret of calcium, evolving carbonic and hydrosulphuric acid gases, and forming chloride of calcium, which remains in solution. The carbonate of soda, used by the Edinburgh College, is for the purpose of detecting the presence of a calcareous salt in the washings.

Purified animal charcoal causes no effervescence when mixed with hydrochloric acid, by which the absence of carbonate of lime is shown. Nor is any precipitate produced by the addition of ammonia, or its sesquicarbonate, to the acid which has been digested in the charcoal, by which the absence of any dissolved calcareous matter is shewn: caustic ammonia would precipitate any phosphate of lime in solution, while its sesquicarbonate would yield a white precipitate with chloride of calcium. Purified animal charcoal, "when incinerated with its own volume of red oxide of mercury, is dissipated, leaving only a scanty ash [about $\frac{1}{200}$th]."—*Ph. Ed.*

Purified animal charcoal is used as a decolorising agent in the preparation of the vegetable alkaloids, and as an antidote to poisons.

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[1] Warington, *Memoirs of the Chemical Society*, vol. ii. p. 326, 1845.—Also, Weppen, *Pharmaceutical Journal*, vol. v. p. 326, 1846.

[2] *Pharmaceutical Journal*, vol. v. p. 325, 1846.

[3] *On Poisons*, p. 84, 1848.

6. ACIDUM CARBONICUM.—CARBONIC ACID.

Formula CO^2. *Equivalent Weight* 22. *Equivalent Volume* 1 or □

HISTORY.—Although the ancients were acquainted with the poisonous properties of carbonic acid gas, Dr. Black, in 1757, was the first who explained its nature. The *spiritus lethalis* of the ancients is evidently this acid, as is also the *spiritus sylvestris* or *gas* of Paracelsus and Van Helmont. *Fixed air, acid vapour,* and *aërial acid,* are other synonymes for it.

NATURAL HISTORY.—It is a constituent of both kingdoms of nature.

a. IN THE INORGANISED KINGDOM.—Carbonic acid is a constituent of the atmosphere. In some parts of the world it is evolved from the earth in large quantities, particularly in old volcanic countries. Thus, in the vicinity of the Lake of Laach, Bischoff estimates the exhalation as equal to 600,000 lbs. daily, or 219,000,000 lbs. (equal to about 1,855,000,000 cubic feet) annually![1] Some of the acid, evolved in the Brohlthal, on the Rhine, is employed by him in the manufacture of chemical preparations on the large scale. D'Arcet has applied the carbonic acid gas, evolved from the mineral waters of Vichy, to the preparation of alkaline bicarbonates.[2] Most persons are familiar, by report, with the *Grotto del Cane,* near Naples. It is a cavity in a rock, through the fissures of which carbonic acid is evolved. It has received its name from the practice of putting dogs into it, who fall down suffocated. Mr. Alfred Taylor[3] analysed the air contained in this grotto, and found that it consisted of 94 per cent. of carbonic acid. The *Valley of Poison,* in Java, which has been described by Loudon, is another spot where this acid escapes from the earth. It is a cavity of an oval form, about three quarters of a mile in circumference, and from thirty to thirty-five feet deep; filled to the height of about eighteen feet with carbonic acid gas. The bottom of it is covered with the skeletons of men and various other animals, who have fallen victims to its destructive operation. If a traveller should be so unfortunate as to enter it, he cannot be sensible of his danger until too late to return. Mr. Loudon thrust a dog in: the animal fell in fourteen seconds. A fowl thrown in appeared to be dead before it reached the ground!!

Carbonic acid gas is frequently met with in mines and wells; and is termed by miners *choke damp* (from the German *dampf,* vapour).

Few mineral waters are without this acid; and in some it exists in such quantity, as to give them a sparkling or effervescent quality (see p. 299)

Lastly, carbonic acid is found (native) in combination with various bases: as with soda, baryta, strontian, lime, magnesia, and the oxides of manganese, zinc, lead, iron, and copper. According to Sir H. De la Beche, the average amount of carbonic acid locked up in every cubic yard of limestone, is about 16,000 cubic feet.

It is produced in the burning of limestone (carbonate of lime) at limekilns, and by the combustion of charcoal, coal, wood, coal gas, the fire-damp of coal-mines, and other combustibles containing carbon.

β. IN THE ORGANISED KINGDOM.—Carbonic acid gas is exhaled by plants in dark or shady places, and hence is met with in greenhouses, especially during the night. Animals develope it in the process of respiration; and, therefore, in crowded rooms, with imperfect ventilation, accidents have sometimes happened from the accumulated carbonic acid. It is produced by the decomposition of organic matters, as during the fermentation of saccharine fluids (hence the danger of descending into brewers' vats), and in the destructive distillation of animal substances. Free or combined carbonic acid is found in the blood, urine, bones, &c.

PREPARATION.—Carbonic acid gas may be procured in various ways, but for ordinary purposes is usually obtained by the action of a mineral acid on carbonate of lime. Soda-water makers and the preparers of the alkaline bicarbonates obtain it by the action of sulphuric acid on common whiting. In the laboratory, hydrochloric acid and white marble are generally employed. It is most readily prepared in a tubulated glass retort, and may be collected over water. The ordinary hydrochloric acid of the shops should be diluted with four or five times its volume of water. In order to deprive it of any hydrochloric vapour, it should be washed by passing it through water. By the reaction of one equivalent of hydrochloric acid on one equivalent of carbonate of lime, we obtain one equivalent of chloride of calcium, one equivalent of water, and one equivalent of carbonic acid.

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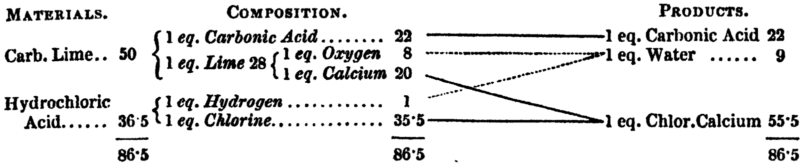
[1] De la Beche, *Theoret. Geology.*

[2] See the description and drawing of the apparatus used, in the *Dictionnaire de l'Industrie, Manufacturier, Commerciale et Agricole,* t. iii. p. 60, art. *Carbonates,* Paris, 1835.

[3] *Med. and Phys. Journ.* Oct. 1832.



By pressure, carbonic acid gas may be condensed into a liquid, called *liquid carbonic acid*. This by an intense degree of cold may be frozen, and converted into *solid carbonic acid*. The necessary degree of cold is obtained by allowing the liquid acid to escape into the air; and by the evaporation of one part, a sufficient cold is produced to freeze another part.[1]

PROPERTIES. *a. Of the gaseous acid.*—At ordinary temperatures and pressures, carbonic acid is gaseous. In this form it is invisible, irrespirable, has a faint odour, and a sharp taste. Its specific gravity is 1·5245. It is neither combustible nor a supporter of combustion, except in the case of potassium, which, when heated in this gas, takes fire, the products of the combustion being carbon and carbonate of potash. It extinguishes most burning bodies when introduced into it in the ignited condition. It reddens litmus feebly.

β. Of the liquid acid.—Under a pressure of 36 [38½, Faraday,[2]] atmospheres at 32°, carbonic acid is a limpid, colourless liquid, which is insoluble in water and in the fat oils, but is soluble in all proportions in alcohol, ether, oil of turpentine, and carburet of sulphur. Its refractive power is less than that of water. Its expansibility by heat is greater than that of gases; for when heated from 32° to 86° F., its bulk increases from 20 to 29 volumes, while the pressure of its vapour augments from 36 to 73 atmospheres.[3]

γ. Of the solid acid.—When the pressure is removed from liquid carbonic acid, by opening a stopcock in the condensing vessel, the cold produced by the evaporation of one part is so great, that another part freezes.

As thus obtained, solid carbonic acid is a white snow-like body. It melts at —70° F., or —72° F., and when resolidified by a bath of low temperature, it then appears as a clear, transparent, crystalline, colourless body like ice (Faraday). In the white snow-form, solid carbonic acid may be handled with impunity, on account of its being a bad conductor of heat, although its temperature is —148° F., or less. But if it be mixed with ether to give it contact, a most intense degree of cold is produced by it. This may be increased by placing the mixture under the exhausted receiver of the air pump. In this way Faraday obtained a temperature of —166° F.

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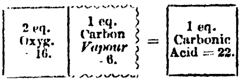
[1] For details respecting the liquefaction and solidification of carbonic acid, see Thilorier, *Ann. Chim. et Phys.* lx. 427, 1835; Adams, in Brande's *Manual of Chemistry*; and Graham's *Elements of Chemistry*, 2d edit. p. 69.

[2] *Phil. Trans.* for 1845, p. 166.

[3] At the Ecole de Pharmacie, in Paris, the apparatus employed in the condensation of the gas burst, and destroyed the *préparateur* (see *Journal de Pharmacie*, t. xxvii.; and *London Medical Gazette*, April 16, 1841).

Characteristics.—Carbonic acid gas is recognised by its feebly reddening litmus, by being incombustible, and a non-supporter of combustion (except in the case above mentioned), and by its forming, with a solution of lime or of baryta, a white precipitate, soluble in acetic acid, or in excess of carbonic acid. Carbonic acid is readily absorbed by a solution of caustic potash.

The *carbonates* effervesce on the addition of hydrochloric acid. The evolved gas is known to be carbonic acid by the characters before stated.



COMPOSITION.—By burning charcoal in one volume or 16 parts, by weight, of oxygen gas, we procure one volume or 22 parts, by weight, of carbonic acid gas.

	Atoms.	*Eq. Wt.*	*Per cent.*	*Dumas et Stas.*	*Saussure.*
Carbon	1	6	27·27	27·27	27·38
Oxygen	2	16	72·73	72·73	72·62
Carb. Acid	1	22	100·00	100·00	100·00

	Vol.	*Sp. gr.*
Carb. vapour[1]	1	0·4189
Oxygen gas	1	1·1056
Carb. Acid gas	1	1·5245

	Vol.	*Sp. gr.*
Carb. Oxide gas	1·	0·9717
Oxygen gas	0·5	0·5528
Carb. Acid gas	1·	1·5245

PHYSIOLOGICAL EFFECTS. α. *On Vegetables.*—Carbonic acid gas is injurious to seeds, and diminishes or stops their germination. An aqueous solution of carbonic acid applied to the roots of plants promotes vegetation. An atmosphere containing not more than 1-8th of its volume of carbonic acid promotes the vegetation of plants exposed to the solar rays, but is injurious to those which grow in the shade.[2] The carbon of plants is derived from carbonic acid, which they take in from the atmosphere, decompose, retain the carbon, and evolve (partially or wholly, according to circumstances) the oxygen. Humus nourishes plants by presenting a slow and lasting source of carbonic acid which is absorbed by the roots.[3]

β. *On Animals.*—The *respiration* of carbonic acid is deleterious and fatal to all classes of animals. It operates as a narcotic or stupefacient poison. That it is a positive poison, and does not act merely by excluding oxygen, as some have supposed, seems to be proved by three facts:—firstly, an atmosphere composed of 79 parts of carbonic acid and 21 of oxygen acts as a poison, although there is as much oxygen present as there is in atmospheric air; secondly, one bronchial tube of the land-tortoise may be tied, without any serious injury to the animal; but if, instead of tying it, the animal be made to inhale carbonic acid gas by it, death takes place in a few hours;[4] and, thirdly, "the cases of insidious poisoning by small doses of carbonic acid scarcely admit of explanation, save on the grounds of the essentially and specifically poisonous action of carbonic acid gas, when sufficiently diluted to become respirable."[5] The impression produced on the pulmonary extremities of the par vagum, by the carbonic acid in the lungs, is supposed by some physiologists to be the ordinary stimulus to inspiration.[1] According to the experiments of Nysten,[2] this gas may be *injected into the venous system* in large quantity, without stopping the circulation, and without acting primitively on the brain; but when more is injected than the blood can dissolve, it produces death by distending the heart, as when air is injected into the veins. *Applied to the skin of animals*, free access of common air to the lungs being preserved, it produces, if the experiment be continued long enough, death.

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[1] The specific gravity of carbon vapour is assumed to be 1·5245 − 1·1056 = 0·4189.

[2] Saussure, *Recherches*, p. 25 et seq. Paris, 1804.

[3] Liebig's *Organic Chemistry in its application to Agriculture and Physiology*, edited by Lyon Playfair, Ph.D. Lond. 1840.

[4] Christison, *Treatise on Poisons*, p. 745, 3d Edit.

[5] Dr. Golding Bird's experiments, in the *Guy's Hospital Reports*, vol. iv. p. 75; also *London Medical Gazette*, new series, vols. i. and ii. for 1838-39.

γ. *On Man.*—If an attempt be made to *inhale* pure carbonic acid gas, the glottis spasmodically closes, so as to prevent the smallest portions from entering the lungs.[3] When mixed with more than twice its volume of air, this gas ceases to provoke spasm of the glottis, and may be taken into the lungs. It then acts as a narcotic poison. Its specific influence is exercised on the central organs of the cerebro-spinal system, which it probably gains access to through the medium of the blood. Its action on the nervous system does not depend on its impeding the arterialization of the blood; because death may occur from the respiration of an atmosphere containing sufficient oxygen to support life *per se*, but with which is mixed carbonic acid gas. It is impossible to state the maximum quantity of this gas which may be present in the air without exciting its effects: it probably varies for different individuals, some persons being much more susceptible of its action than others. If the proportion of carbonic acid be large, the effects are almost immediately developed; whereas, if the proportion be small, they are very slowly manifested. Dr. G. Bird has shewn that an atmosphere containing five per cent. of carbonic acid proved fatal to a bird in thirty minutes; and it is probable that the continued respiration of an atmosphere containing a very considerably smaller proportion of carbonic acid, would be attended with dangerous and even fatal consequences.

The earliest symptom usually experienced by persons exposed to an atmosphere containing carbonic acid gas is throbbing headache, with a feeling of fulness and of tightness across the temples, and in the occipital region. Giddiness, loss of muscular power, a sensation of tightness at the chest, augmented action of the heart, and often palpitation succeed. The ideas become confused, and the memory partially fails. A buzzing noise in the ears is next experienced; vision is impaired; and a strong tendency to sleep succeeds, or actual syncope ensues. The pulse falls below its natural standard, the respiration becomes slow and laborious, the surface cold and often livid, but the eyes retain their lustre. Convulsions, sometimes accompanied with delirium, foaming at the mouth, and vomiting, come on, and are terminated by death. On post-mortem examination, engorgement of the cerebral vessels, and sometimes serous or even sanguineous effusion, are the usual appearances.[4]

Applied to the skin (care being taken that it be not inhaled) it produces a sensation of warmth and prickling or tingling, sometimes accompanied by pain, increased frequency of the pulse, sweating, and excitement of the nervous system.

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[1] Dr. M. Hall *On the Diseases and Derangements of the Nervous System*, p. 66, Lond. 1841.

[2] *Recherches*, p. 88.

[3] Davy, *Researches*, p. 472.

[4] For further details, I must refer the reader to Dr. Bird's paper before cited.

M. Collard de Martigny (quoted by Dr. Christison) experienced weight in the head, obscurity of sight, pain in the temples, ringing in the ears, giddiness, and an undefinable feeling of terror. *Taken into the stomach,* dissolved in water, or in the form of effervescing draughts, it allays thirst, and diminishes preternatural heat, thus acting like the other dilute acids. If it be evolved in the stomach, it distends this viscus, excites eructations, and checks both nausea and vomiting. It appears to promote the secretions of the alimentary tube, to assist the digestive process, to allay irritation, and to act as a refreshing and exhilarating substance. It is said to be diuretic and diaphoretic. But Wöhler and Stehberger expressly state, that the use of carbonic acid did not increase the quantity of this substance in the urine.[1] When drunk too quickly, and in large quantity, water impregnated with this gas has been known to excite giddiness and intoxication;[2] and it is probable that champagne is indebted to this substance for part of its intoxicating powers. *Applied to ulcers and suppurating surfaces,* carbonic acid gas acts as a stimulant, improves the quality of the discharge in ill-conditioned and indolent ulcers, retards the putrefaction of the secreted matters, diminishes the unpleasant odour of foul and gangrenous sores, and promotes the separation of the dead and mortified parts.

USES. *a. When inhaled.*—In some diseases of the lungs, particularly phthisis, it has been proposed to mix carbonic acid gas with the atmospheric air breathed by the patient, with the view of lessening the stimulant influence of the oxygen, to diminish the quantity and improve the quality of the matter expectorated, and at the same time to relieve the hectic symptoms. But the practice is dangerous. Part of the benefit said to have been derived by consumptive patients from a residence in cow-houses, has been ascribed to the inhalation of carbonic acid gas (see p. 19).

β. Taken into the stomach, carbonic acid is a most valuable remedy for checking vomiting, and diminishing irritable conditions of this viscus. The best mode of exhibiting it is, I believe, in the form of an effervescing draught, composed of citric acid and bicarbonate of potash. In fever, it is an excellent refrigerant; being especially serviceable in those cases which are accompanied with gastric irritation. In that form of lithiasis attended with a white or phosphatic deposit in the urine, carbonic acid water may be taken with advantage; but in this case the common effervescing draught (made of a vegetable acid and a carbonated alkali) must not be substituted for it, on account of the alkaline property communicated by the latter to the urine (see *ante*, p. 180). From its antiseptic qualities, carbonic acid has been administered internally, in those diseases which are supposed to be connected with a putrescent tendency, as typhoid fevers, &c.[3]

γ. Clysters of carbonic acid gas have been employed in certain affections of the rectum and colon,—for example, ulceration of the rectum, especially when of the kind commonly denominated cancerous. Mr. Parkin[4] has recommended them in dysentery. The gas may be introduced into the rectum from a bladder, or solutions of tartaric acid and bicarbonate of soda may be injected in the usual way.

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[1] Tiedemann's *Zeitschrift für Physiologie*, Bd. i. & ii.

[2] Fodéré, *Méd. Légale.*

[3] See Dobson's *Medical Commentary on Fixed Air*, 2d

[4] *On the Efficacy of Carbonic Acid Gas in the Diseases of Tropical Climates, with Directions for the Treatment of Acute and Chronic Stages of Dysentery.* Reviewed in the *London Medical Gazette*, vol. xviii. p. 777, 1836.

δ. *A stream of carbonic acid gas* has been applied to the *uterus* with great benefit, in a painful condition of this viscus, as I have already mentioned (see p. 131).

ε. *Applied to the skin*, care being taken that the gas be not inhaled, it is employed either in its gaseous form, or dissolved in water. It is, of course, adapted to those cases where it is desirable to excite the vascular system, especially of the skin, and to cause perspiration; while, on the other hand, it is objectionable in inflammatory cases. In chlorosis, amenorrhœa, dyspepsia, hysteria, scrofula, &c., it has also been found useful.

ζ. It has been *applied to cancerous and other ulcers*, to allay pain, to improve the quality of the secretions, and to check sloughing. It is readily administered by means of a tube connected with a bottle generating the gas. In this case it should be procured by the action of dilute sulphuric acid on marble; for, if hydrochloric acid be employed, the gas requires washing, to remove any of this acid which may pass over with it. Or it may be used in the form of solution, in which case carbonic acid water is employed. Or, lastly, we may apply the *yeast poultice* (see *cataplasma fermenti*).

η. *In ophthalmia*, of a chronic kind, a stream of carbonic acid gas, directed on the inflamed part, has appeared to be serviceable. I have seen it used in a case of scrofulous ophthalmia: the patient recovered under its use, after the ordinary plans of treatment had been unsuccessfully tried.

ADMINISTRATION.—Internally, carbonic acid may be administered under the form of *carbonic acid water* or the *effervescing draught*. The latter, however, cannot always be employed as a substitute for the former. Where no objection exists to the use of the vegetable salts of potash, the ordinary *effervescing draught* may be administered. In febrile disorders, when the stomach is in a very irritable condition, I prefer a draught made with citric acid and the bicarbonate of potash, to other modes of employing carbonic acid.

Another mode of administering carbonic acid is under the form of the *acidulous* or *carbonated mineral waters* (see *ante*, p. 299).

ANTIDOTES.—In accidents arising from the inhalation of carbonic acid gas, proceed as follows:—Remove the patient immediately into the open air, and place him on his back, with his head somewhat elevated. Produce artificial respiration by pressing down the ribs, forcing up the diaphragm, and then suddenly removing the pressure. Dash cold water over the body, and abstract a small quantity of blood either by venesection or cupping. Apply bottles of hot water to the feet. Stimulants of various kinds may be employed, either internally by the stomach, or in the form of frictions, or inhalations of ammonia, or air impregnated with chlorine gas.

AQUA ACIDI CARBONICI; *Carbonic Acid Water; Bottle Soda Water; Soda Water from the Fountain; Artificial Seltzer Water.*—This is prepared by condensing carbonic acid gas (generated by the action of sulphuric acid on whiting) in water. The operation is effected by means of *Tyler's Improved Soda-Water Apparatus* (figs. 49 & 50).[1]

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[1] These figures are taken from Ure's *Dict. of Arts and Manufactures*, p. 1156, Lond. 1839.—See also *Pharmaceutical Journal*, vol. v. p. 365.

A. Lead generator for making the gas. *B*. Lead pot for holding sulphuric acid. *C*. Handle for moving the agitator of the receiver, which stirs up the ingredients in the lead generator. *a*. Cap and screw for charging the lead pot with sulphuric acid. *b*. Swivel-joint, which is moveable, for occasionally throwing in portions of sulphuric acid for generating gas. *c*. Stuffing-box for agitator. *d*. Large cap and screw for charging the lead generator with whiting and water. *e*. Cap and screw for emptying contents of ditto. *D*. Lead pipe to convey the gas from the lead generator to gasometer. *E*. Wood tub, filled with water, for gasometer to work in. *F*. Copper gasometer. *G*. Strong iron frame for gasometer and tub to stand on, firmly fixed together by three wrought-iron rods, *ff*. *gg*. Two pulleys for carrying rope and counterbalance weight, *h*, for balancing copper gasometer. *i*. Cock for discharging atmospheric air contained in the gasometer before making the gas. *k*. Cock for occasionally emptying the water out of the tub. *l*. Union-joint, to which is fixed a copper pipe, passing through the water in the tub, to deliver the gas as generated into the copper gasometer. *m*. Another union-joint, with a similar copper pipe passing through the water in the tub, and projecting two or three inches above the surface of the water, to convey the gas from the copper gasometer to the soda-water machine. *HH*. Condenser for aërating the soda water. *I*. Safety valve. *KK*. Bottling valve. *L*. Bottling nipple. *MM*. Soda water pump. *N*. Valve-piece. *OO*. Piston of the pump. *P*. Pipe for conducting gas from the gasometer to pump. *Q*. Copper pan for holding the water or solution of soda. *R*. Copper pipe for conducting the solution of soda to the force pump. *SS*. Two cocks for regulating the admission of the solution and gas to the pump. *T*. Copper pipe through which the soda water is forced to the condenser. *U*. Pinion wheel, to give motion to the agitator revolving inside the condenser. *VV*. Wheel for driving ditto. *WW*. Cast-iron frame carrying machinery. *XX*. Cast-iron fly-wheel. *Y*. Wrought-iron crank. *ZZZ*. Wood stools and curb, upon which the whole of the machinery is fixed.

FIG. 49.

FIG. 50.

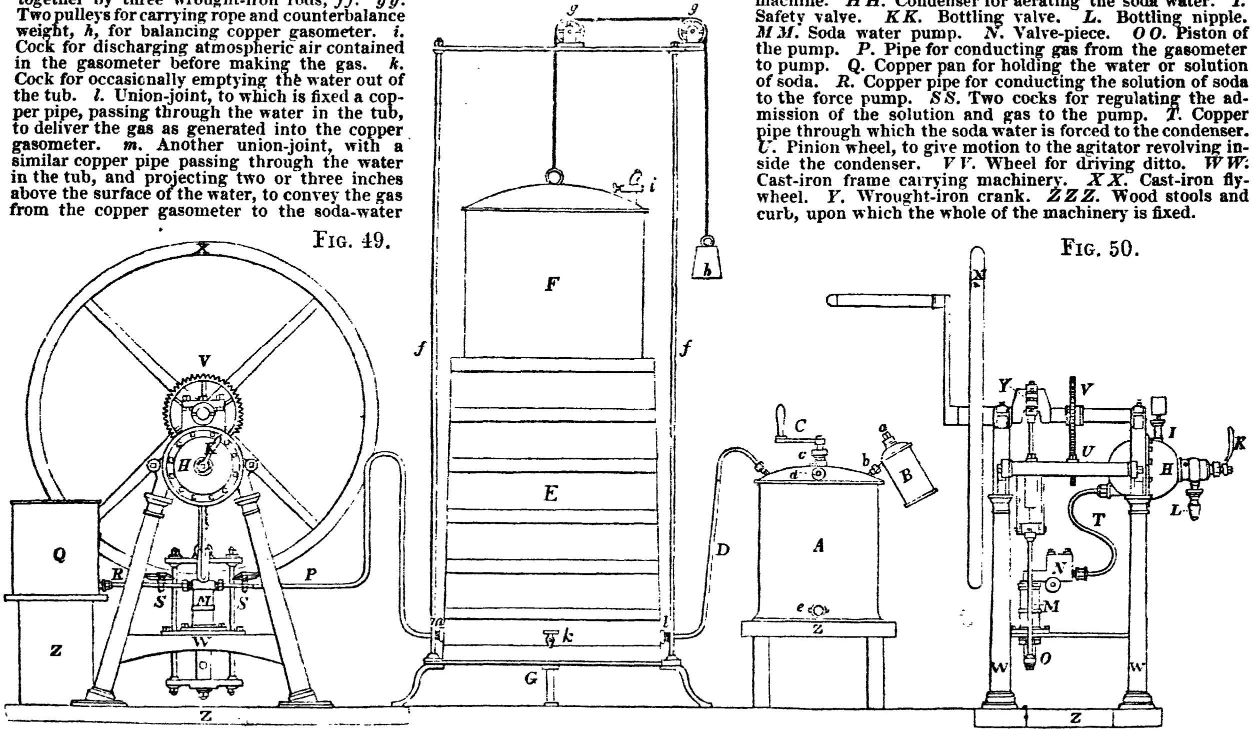

FIG. 49. Front View of the Machine. *Tyler's Improved Soda Water Apparatus.* FIG. 58. End View of the same.

At the ordinary temperature and pressure of the atmosphere, one volume of water absorbs one volume of carbonic acid gas, and acquires a sp. gr. of 1·0018. By doubling the pressure, the quantity of gas absorbed by the water is doubled, and so on for other degrees of pressure; for Dr. Henry has shown, that the quantity of gas forced into the water is directly as the pressure. In the United States' Pharmacopœia five volumes of gas are directed to be condensed in one volume of water. Mr. Webb tells me that a pressure of eleven atmospheres is used in the preparation of his soda water.

The *Bottle Soda Water* of the shops is, in general, carbonic acid water only. Mr. Webb, and some few other manufacturers, introduce a small portion of soda (see *aqua sodæ supercarbonatis*).

Carbonic acid water is a brisk, sparkling liquid. It is a pungent, acidulous taste; reddens litmus; and causes, with lime water, a white precipitate (*carbonate of lime*), which is re-dissolved by an excess of carbonic acid water.

Some of the bottle soda water sold in the shops is contaminated with lead, which it derives either from being prepared in leaden vessels or from its passage through leaden pipes. The presence of lead may be detected by the addition of sulphuretted hydrogen or hydrosulphuret of ammonia, which occasions a dark colour or black precipitate (*sulphuret of lead*).

Carbonic acid water is a refreshing, refrigerant beverage, operating as an anti-emetic, diaphoretic, and diuretic. In febrile disorders it is used to allay thirst, check nausea, and promote secretion. In lithiasis it is employed to check the formation of the phosphates in the urine. It is a convenient vehicle for the exhibition of many medicines, the nauseating qualities of which it diminishes. By the aid of it, extemporaneous imitations of carbonated magnesian and carbonated chalybeate water may be readily made (see *aqua magnesiæ supercarbonatis*, and *aqua ferri supercarbonatis*).

For domestic use, especially in the sick-chamber, Mayo's *patent syphon vase*[1] is a convenient receptacle for carbonic acid water. From this vessel, the effervescing liquid may be drawn off, at pleasure, in any required quantity without explosion, loss, or injury to the residue in the vase.

ORDER IV. BORON AND ITS COMPOUND WITH OXYGEN.

BORON, *boracium*, or *borium*. Symbol B. Equivalent weight 11. It is odourless and tasteless; but, beyond this, its effects on the system are unknown. It has never been employed in medicine.

7. ACIDUM BORACICUM.—BORACIC ACID.

HISTORY.—Beecher[2] "was undoubtedly the first discoverer of boracic acid, though the credit of the discovery has usually been given to Homberg," who, in 1702,[3] obtained it in small shining plates, which have been called *sedative* or *narcotic salt* (*sal sedativum Hombergi*). In the year 1776 it was discovered in the lagoons (*Lagoni*) of Tuscany by Hoefer[1] and Mascagni,[2] and more recently by Mr. Smithson Tennant,[3] Dr. Holland,[4] and Mr. Lucas,[5] in the crater of Vulcano, one of the Lipari Islands.

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[1] *Pharmaceutical Journal*, vol. v. p. 255.

[2] Thomson's *History of Chemistry*, vol. i. p. 248, Lond. 1830.

[3] *Histoire de l'Académie Royale des Sciences*, 1702; *Mémoires*, p. 50.

NATURAL HISTORY.—Boracic acid is peculiar to the inorganized kingdom. It is found both free and combined.

a. Free Boracic Acid.—The boracic acid *lagoons* of Tuscany are spread over a surface of about thirty miles. There are nine establishments for the manufacture of this acid; viz. at Monte Cerboli, Monte Rotondo, Sasso, Serazzano, Castelnuovo, San Frederigo, Lustignano, Lurderello, and Lago. They are the property of one individual (M. Tarderel, now Count de Pomerance), to whom they are the source of great wealth. The earth (principally calcareous) of this part continually evolves aqueous and sulphuric vapours, which, when they burst with a fierce explosion, produce boracic acid.[6] The phenomena are explicable on the supposition, that water gains access to immense masses of sulphuret of boron contained in the interior of the earth. By the mutual reaction of these substances, great heat, boracic acid, and sulphuretted hydrogen, would be evolved. The latter taking fire would produce water, sulphur, and sulphurous acid.[7] In consequence of being found at Sasso, native boracic acid has obtained the name of *sassoline*.

β. Combined with bases.—Boracic acid is found native combined with soda (forming *tincal*), and with magnesia (constituting *boracite*). It is also found in the minerals called *datholite*, *botryolite*, *schorl*, *apyrite*, and *axynite*.

PROCESS OF MANUFACTURE.—Boracic acid is obtained in Tuscany in the following manner:—"Round the more considerable fissures a circular basin is dug, about four feet deep, and usually three or four yards across. These basins, which are called *lagoni*, being situated at different levels, the water of a rivulet is admitted into them, which, mixing with the black mud at the bottom, is made to boil up violently by the issues of vapour within its circuit. The water is generally confined in each basin for twelve [twenty-four, *Payen*] hours at a time, during which period it becomes saturated to a certain extent with acid from the steam which has passed through it. It is then drawn off from the higher basin to one beneath it, where it remains an equal length of time, till at length it reaches a building at the bottom of the hill, in which the process of evaporation is conducted." Here it enters a reservoir or cistern, where it is allowed to repose till it has deposited the mud which it held in suspension. Having cleared itself of impurities, the water is then drawn off from the cistern into flat leaden pans, under which some of the natural steam is conducted by brick drains about two feet under ground, and by this heat is evaporated. This process requires about sixty hours, the water passing successively from the pans at the upper extremity into others at the centre, and from thence into others at the lower extremity of the building, by means of leaden siphons.

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[1] *Memoria sopra il sale sedativo di Toscana ed il Borace*, &c. Firenze, 1788.—Uebers. von B. F. Hermann, Wien, 1782.

[2] *Memorie della Societa Italiana*, viii. 487.

[3] *Transactions of the Geological Society*, vol. i. p. 388, 1811.

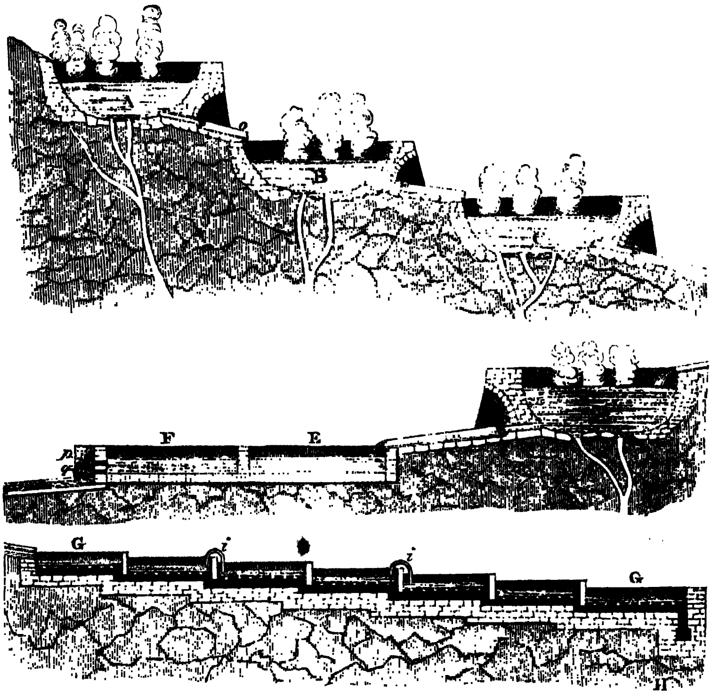
[4] *Travels in the Ionian Islands, Albania, Thessaly, Macedonia, &c. during the years* 1812-13, p. 9, Lond. 1815.

[5] *Ann. Chim. et de Physiq.* t. ii. p. 443, 1819.

[6] For further details, consult Taucred, *On the Collection of Boracic Acid from the Lagoni of Tuscany*, in the *Transactions of the Ashmolean Society*, vol. i. Oxford, 1837; Dr. Bowring, *On the Boracic Acid Lagoons of Tuscany*, in the *Lond. and Edinb. Philosophical Magazine*, vol. xv. p. 21, Lond. 1839; and Payen, *Ann. Chim. et Phys.* 1841.

[7] Dumas, *Traité de Chimie*, t. i. p. 380, Paris, 1828.

Fig. 51.



Boracic Acid Lagoons of Tuscany.

A, B, C, D. Lagoons.—The vapours enter at the bottom, and escape through the water into the air. When the water in the upper Lagoon, A, is sufficiently charged with acid, it is allowed to run through the tube, *o*, into the lower lagoon, B. In this way it passes successively from B to C, from C to D, and from D into the reservoir E.

E, F. Reservoirs or Cisterns.—In these the solution is allowed to rest, and deposit mechanical impurities. By the removal of the upper plug, *p*, the solution escapes into the upper evaporating pan, G.

G, G. Leaden Evaporating Pans.—They are supported by rafters, and are heated by the aqueous vapours which enter at H, and are confined in drains. The acid solution is conveyed from one pan to another by means of leaden siphons, *i*, *i*.

Having arrived at a proper state of concentration, it is then conducted into wooden tubs, in which it cools for about five days, during which the crystallization of boracic acid takes place on the sides of the tubs, and on the stick in the centre. The acid having been removed from the tubs is placed in a basket to drain, and is then spread on the floor of a closed chamber, heated by vapour, to dry. The acid, thus prepared, is sent in casks to Leghorn.[1]

The acid obtained by this process is called *Tuscany boracic acid.* It has a slight yellow or buff tint; and its composition, according to Wittstein,[2] is as follows:—

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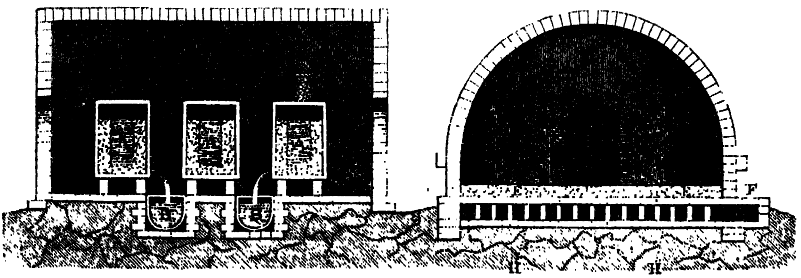
[1] Tancred, *op. supra cit.*; also Bowring, *op. supra cit.*; and Payen, *op. supra cit.*

[2] Buchner's *Repertorium*, 2te Reihe, Bd. xxii. p. 145, 1840.

Boracic acid (crystallized)	76·494
Sulphate of ammonia	8·508
Sulphate of magnesia	2·632
Sulphate of lime	1·018
Sulphate of soda	0·917
Sulphate of potash	0·369
Sulphate of iron	0·365
Sulphate of alumina	0.320
Sulphate of protoxide manganese	traces
Chloride of ammonium	0·298
Silicic acid	1·200
Sulphuric acid (combined with boracic acid)	1·322
Water	6·557
Organic matter	traces
	100·000

FIG. 52.



Crystallization and Drying Chambers.

A, A, A. Wooden tubs lined with lead, in which the acid crystallizes.
B, B. Mother liquor.
C. Basket in which the crystallized acid is placed to drain before it is conveyed to the drying chamber.
D, D. Drying chamber.
E, E. Boracic acid drying on the floor (F), between which and the lower floor (H) the hot vapour circulates.

Tuscany boracic acid is purified, after its arrival in this country, by solution and crystallization.

Boracic acid may also be obtained by dissolving borax in hot water, and adding half its weight of oil of vitriol. As the solution cools, crystals of boracic acid (retaining a little sulphuric acid) are deposited, which must be well washed. Or borax may be decomposed by hydrochloric acid, by which a purer boracic acid is procured.[1]

PROPERTIES.—Crystallized boracic acid belongs to the doubly oblique prismatic system (see *ante*, p. 143). It occurs in the form of white, transparent, pearly, hexagonal scales, which are odourless, have a weak, scarcely acid, taste, and communicate a wine-red tint to litmus. At 60° the crystallized acid requires 25·66 times its weight of water to dissolve it, but only 2·97 times at 212°. When its solution is boiled a portion of the acid is volatilized along with the water. It dissolves readily in spirit of wine. When sufficiently heated, it evolves its water of crystallization, melts, forming a transparent liquid, which, by cooling, becomes a brittle glass (*vitrified boracic acid*).

Characteristics.—An alcoholic solution of boracic acid burns with a beautiful green flame. "If a salt is suspected to contain boracic acid, a little sulphuric acid may be added, and the mixture dried by a gentle heat: this will separate the boracic acid, and if any chlorine or hydrochloric acid be present (which also gives a greenish-blue flame) it will be dissipated. Alcohol is then poured upon the dry mass, and a bit of cotton moistened and inflamed: if the quantity of boracic acid is very minute, the green tint does not at first appear: but after a time, especially if the cotton be moved about with a glass rod, the point of the flame assumes a green hue: the absence of copper must always be ensured" (Brande). A hot aqueous solution of the acid renders turmeric paper brown, like the alkalies.[1] The colour of rhubarb paper is unchanged by it. Before the blowpipe, boracic acid fuses, and forms a glass which may be tinged blue by chloride of cobalt, and rose-red by terchloride of gold. A red hot platinum wire dipped into a pulverised mixture of equal parts of a boracic salt and bisulphate of potassa gives a green tint to the flame of the blowpipe. A mixture of one part of vitrified boracic acid, finely pulverised, two parts of fluor spar, and twelve parts of oil of vitriol, evolves, by heat, the fluoride of boron, recognized by its forming dense white fumes in the air, and by its charring paper, wood, &c.

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[1] *Pharmaceutical Journal*, vol. ii. p. 51.

COMPOSITION.—The following is the composition of boracic acid:—

	Atoms.	*Eq. Wt.*	*Per Ct.*	*Berzelius.*
Boron	1	11	31·43	31·1896
Oxygen	3	24	68·57	68·8104
Dry Boracic Acid	1	35	100·00	100·0000

	Atoms.	*Eq. Wt.*	*Per Ct.*	*Davy.*	*Berzelius.*
Dry Boracic Acid	1	35	56·45	57	56
Water	3	27	43·55	43	44
Crystallised Boracic Acid	1	62	100·00	100	100

PHYSIOLOGICAL EFFECTS AND USES.—Homberg ascribed to this acid sedative, anodyne, and antispasmodic properties. It was said to be useful in ardent fever, delirium, nervous affections, convulsions, &c., and to be devoid of the inconveniences which attend the use of opium, though it was thought to be injurious in persons with delicate chests, and in inflammatory affections of the *primæ viæ*. Experience, however, has not confirmed these opinions; and it is now considered to be inert or nearly so. Cullen[2] gave it in large doses without observing that it produced any effect on the human body. It is, therefore, not employed directly in medicine; but it is extensively used in the manufacture of borax. (See *Sodæ Biboras*.)

ORDER V. PHOSPHORUS AND PHOSPHORIC ACID.

8. PHOSPHORUS.—PHOSPHORUS.

Symbol P. *Equivalent Weight* 32. *Equivalent Volume of Phosphorus Vapour* 0·5 or ▭

HISTORY.—This substance was discovered, in 1669, by Brandt, an alchymist at Hamburgh; and received its name from being luminous in the dark (from φῶς, *light*, and φέρω, *I carry*).

NATURAL HISTORY.—Phosphorus is found in both kingdoms of nature.

a. IN THE INORGANISED KINGDOM.—It is comparatively rare in the mineral kingdom. Various phosphates are found native, but in small quantities: those of lime, lead, iron, copper, manganese, uranium, and yttria, may be mentioned as examples. Phosphate of lime is an important constituent of the organic exuviæ entombed in the fossiliferous rocks. It is a constituent of the deep-well water of the London basin (see p. 290).

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[1] Faraday, *Quarterly Journal of Science*, vol. ix. p. 403.

[2] *Materia Medica*, p. 341.

The luminous appearance called *jack with a lantern* has been ascribed to phosphuretted hydrogen.

β. IN THE ORGANISED KINGDOM.—Phosphoric acid, free or combined with lime, potash, or iron, is found in various vegetables.[1] Phosphorus is a constituent of animals: in some cases it is in combination with oxygen, and a base, as in the bones, urine, &c.; in other instances, as in the brain, it is uncertain in what form it exists.

PREPARATION.—Phosphorus is usually obtained from bone-ash. When bones are burned in the air to whiteness, the ash which remains consists principally of phosphate and carbonate of lime, mixed with minute portions of other matters (see *ante*, p. 314). The phosphate of lime of bones is according to Berzelius $8CaO,3PO^5$; but more recent investigations lead to the conclusion that it is a tribasic phosphate, $3CaO,PO^5$. The bones of the sheep are preferred for yielding phosphorus, as the ash which they yield is less compact, and more easily attacked by acid. Sulphuric acid is gradually added to the bone-ash previously made into a thin paste with water. Carbonic acid is evolved, while sulphate and a soluble superphosphate of lime are formed. Water is added, and at the end of twenty-four hours the liquor is filtered and evaporated in leaden or copper pans to the consistence of syrup or honey. It is then mixed with charcoal, dried, and distilled in an earthen retort. The charcoal abstracts the oxygen from the phosphoric acid of the superphosphate, setting free the phosphorus, which is volatilized, and condensed in water contained in a copper receiver. It is afterwards purified by pressing it through shamoy leather under water. It is subsequently moulded for sale into cylinders, by melting it in water, and sucking it up a slightly conical glass tube, which is then immersed in cold water, when the solidified stick of phosphorus falls out.[2] Another mode of giving the stick-form to phosphorus has been suggested by Seubert.[3] It consists in letting melted phosphorus flow into horizontal glass tubes, one extremity of each tube being surrounded by warm water (111° Fahr.) the other by cold water. The phosphorus when solid is removed from the tube, and thus makes room for a fresh supply, which again solidifies, and thus a stick of any length may be formed.

Wöhler[4] obtained phosphorus by distilling two parts of bone black with one of quartz sand at a white heat. The silicic acid of the sand decomposed the phosphate of lime contained in the bone black, and disengaged the phosphoric acid which was de-oxidized by the carbon.

PROPERTIES.—It is colourless, and when it has been solidified slowly it is transparent; but when rapidly, it is cloudy, and has a waxy lustre. It crystallizes in regular octohedrons and rhombic dodecahedrons. Its sp. gr. is 1·896. At 32° F. it is brittle, but at ordinary temperatures is somewhat flexible. At 94° F. it is very brittle, and may be easily pulverized; at 110° F. it melts, and forms an oily-like liquid. At 482°, Heinrich (550°, Dalton; 574°, Pelletier), it boils, and yields a colourless vapour whose sp. gr., according to Dumas, is 4·355. Both solid and liquid phosphorus is a non-conductor of electricity. At ordinary temperatures it evolves a small quantity of vapour. In the atmosphere its fumes are luminous in the dark, in consequence of slow combustion; and they have the odour of garlic. Phosphorus is insoluble in water, but soluble in ether and in the oils both fixed and volatile.

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[1] De Candolle, *Phys. Végét.* pp. 383, 387, and 390.

[2] For further details, consult Soubeiran, *Nouveau Traité de Pharmacie*, t. ii. p. 260, 2de édit. also Ure, *Dict. of Arts.*

[3] *Pharmaceutical Journal*, vol. iv. p. 129.

[4] Poggendorff's *Annalen*, xvii. 178, 1829.

Preservation.—Phosphorus should be preserved in a stoppered vessel filled with water and kept in the dark (as inclosed in a tin box).

Granulation.—Phosphorus may be granulated by melting it under water and shaking it in a closed vessel until it is cold. According to Casaseca,[1] proof spirit is better than water for this purpose. Böttger states that human urine, or an artificial solution of urea, succeeds best. He half filled a tall cylindrical vessel of an inch wide with this fluid, heated it to the melting point of phosphorus, divided this for two minutes by means of a whisk (*Quirl*), which passed through a wooden lid, and during the agitation filled up the vessel with cold water.

VARIETIES.—In the text, phosphorus is described as being colourless and transparent, or nearly so. In commerce, however, it is frequently met with coloured and opake.

1. *Yellow or red phosphorus.*—Commercial phosphorus is frequently of a yellow, pale buff, or reddish colour. Colourless phosphorus becomes thus coloured under the influence of the direct solar rays or violet light. The red crust which forms on sticks of phosphorus when exposed to light is an *oxide of phosphorus*, P^2O.

2. *White phosphorus.*—Phosphorus kept under water and exposed to diffused daylight acquires a white opake coating. Different opinions exist as to the nature of this crust. Rose considers it to be merely phosphorus in a different state of aggregation. Pelouze regards it as a *hydrate of phosphorus*, P^2, HO. Mulder thinks that it is a compound of the red oxide of phosphorus and phosphuretted hydrogen; these two compounds being formed by the decomposition of water.

3. *Black phosphorus.*—If phosphorus be heated to 140° F. or 158° F., and then suddenly cooled to 32°, it sometimes becomes black. Thenard, who first observed this phenomenon, found that all kinds of phosphorus do not undergo this change, but only that which has been repeatedly distilled.—Dumas speaks of a blackish phosphorus which distils over towards the end of the process in making phosphorus; and he says that it is usually supposed to be combined with carbon, but he thinks that it is more probably with silicium.—The blackish French phosphorus described by Wittstock[2] contained arsenic, bismuth, lead, iron, copper, and especially much antimony. It yielded by solution in sulphuret of carbon brown flocculi of sulphuret of antimony.

Characteristics.—Phosphorus, in substance, is easily recognized by its waxy appearance and garlic-like odour; by its fuming in the air, and being phosphorescent or luminous in the dark; by friction or gentle heat causing it to inflame; and, lastly, by its burning with a most intense white light and a white smoke (phosphoric acid) in air, or still better in oxygen gas. A solution of phosphorus in oil or ether may be known by its garlick-like odour, and, when rubbed on the skin, by its rendering the latter luminous in the dark.

By boiling in nitric acid phosphorus is converted into phosphoric acid, the characteristics of which are given hereafter.

IMPURITIES.—The best phosphorus is colourless, transparent, or only slightly cloudy, and breaks with a short crystalline fracture.

Dumas appears to regard flexibility as a characteristic of good phosphorus: for he says that the same stick may be bent seven or eight times in different directions without breaking; but, he adds, the addition of $\frac{2}{800}$ths of sulphur is sufficient to render it brittle.

Commercial phosphorus sometimes contains sulphur or arsenic,[3] or both. Wittstock obtained 3·654 grains of metallic arsenic from one ounce of phosphorus:—equal to 0·761 per cent. Occasionally, also, it contains antimony and some other metals above noticed. Probably all these impurities are derived from the sulphuric acid employed in decomposing the bone ash.

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[1] *Journ. de Pharmacie*, xvi. 202.

[2] *Berl. Jahrb. für d. Pharmacie*, Bd. xxxiii. Abt. ii. p. 146, 1833.

[3] Baerwald, *Berl. Jahrb. für d. Pharmacie*, Bd. xxxiii. Abt. ii. p. 113, 1833; also Wittstock, *ibid.* p. 125.

When this acid has been prepared from arsenical pyrites it contains arsenious acid, which becomes reduced in the process for making phosphorus; and Wittstock suggests that the black phosphorus which he found to contain antimony, &c. had been prepared with oil of vitriol made with native sulphuret of antimony.

Detection.—A solution of pure phosphorus in diluted nitric acid yields, with a solution of a barytic salt, a precipitate which is soluble in excess of nitric acid. But if phosphorus yield a precipitate insoluble in this acid, the presence of sulphuric acid (formed by the oxidation of sulphur) may be inferred.

The presence of arsenic in phosphorus may be detected as follows:—Convert the phosphorus into phosphoric acid by boiling in nitric acid; dilute the solution with water, and transmit sulphuretted hydrogen through it; if arsenic be present, a yellow precipitate is obtained.—By evaporating a solution of phosphorus in dilute nitric acid, a blackish arsenical deposit is obtained: the phosphorous acid contained in the solution deoxidizes the arsenic.

Purification.—Redistillation will not deprive phosphorus of its contained arsenic. By repeated digestion in diluted nitric acid, the greater part, or the whole, of it may be removed. Wöhler[1] says that opake yellow or red phosphorus may be rendered transparent and colourless by melting it in a concentrated solution of bichromate of potash to which sulphuric acid has been added. The vessel should be stoppered, and shaken strongly to divide the phosphorus into fine globules.

PHYSIOLOGICAL EFFECTS. α. *On Vegetables.*—According to Marcet it is poisonous to plants.

β. *On Animals generally.*—Water impregnated with phosphorus acts as an aphrodisiac to drakes.[2] Phosphuretted oil is a stimulant to horses: blood drawn from the veins of horses under its influence has a phosphoric odour.[3] If phosphuretted oil be injected into the jugular vein, or into the cavity of the pleura of a dog, white vapours of phosphorus are evolved from the mouth, and death shortly takes place. The phosphorous acid (formed by the combustion of the phosphorus) inflames the lungs in its passage through the delicate pulmonary vessels. Introduced into the stomach of animals, phosphorus acts as a caustic poison. The corrosion is supposed to depend on the action of the phosphorous acid (formed by the combination of the phosphorus with the oxygen of the air contained in the pulmonary canal) on the tissue with which it is in contact.[4]

γ. *On Man.*—The general stimulant operation of phosphorus has been already alluded to (see *ante*, p. 226), as well as its chemical action (see *ante*, p. 93). In *small doses* phosphorus excites the nervous, vascular, and secreting organs. It creates an agreeable feeling of warmth at the epigastrium, increases the frequency and fulness of the pulse, augments the heat of skin, heightens the mental activity and the muscular powers, and operates as a powerful sudorific and diuretic. Its aphrodisiac operation has been recognized by Alphonse Leroy and Bouttatz[5] by experiments made on themselves; and the facts collected by Dr. Hartcop bear out this statement (Mr. A. Taylor). In *somewhat larger doses*, it causes burning pain, vomiting, and purging, with extreme sensibility of the stomach, which lasts for several days.[1] In *still larger doses* it causes inflammation of the stomach and bowels. Its activity as a caustic poison depends, according to Orfila, on its absorbing oxygen, and thus becoming converted into an acid which acts as a corrosive, like the other mineral acids. Hence, therefore, ethereal and oleaginous solutions are more active poisons, inasmuch as the oxidation of the phosphorus is effected more rapidly. Comparatively small doses have in some cases proved fatal. Dr. Christison[2] mentions one instance in which 1½ grains, in another instance 3 grains, caused death.[3] Cases, however, are reported, in which 6, 10, and even 12 grains have been swallowed without any hurtful effects; but doubts have been entertained as to the correctness of the statements. Thus Mérat and De Lens[4] think that the phosphorus employed in these cases must have undergone some chemical change. I once administered 16 grains of apparently good phosphorus to a man without any injurious effect. The person here alluded to was Chabert, some years ago renowned in London under the name of the "*Fire King*." I carefully weighed the above quantity, which was placed in a spoon, introduced into his mouth, and washed down by a tumblerful of water. He offered to take this dose daily. Within ten minutes after swallowing the phosphorus, he left the room for about a quarter of an hour.

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[1] *Ann. der Chem. u. Pharm.* Bd. xlv. p. 249, 1843.

[2] Alph. Leroy, quoted by Bayle, *Biblioth. de Thérap.* t. ii. p. 28, Paris, 1830.

[3] Pilger, quoted by Bayle.

[4] Orfila, *Toxicol. Génér.*

[5] Bayle, *op. cit.*

A case of suspected poisoning by phosphorus administered medicinally is reported by Mr. Reedal:[5] but the total amount of phosphorus which was taken is not stated; and it is by no means certain that the death was owing to it. Post-mortem examination shewed the existence of inflammation of the cæcum and colon.

During the last three years, the attention of the profession in Germany, France, and England,[6] has been drawn to the occasional occurrence of necrosis of the jaw-bone in work-people engaged in the manufacture of lucifer and congreve matches. The disease appears to be a secondary consequence of periostitis, which is probably produced by the fumes from phosphorus employed in the above manufacture; though by some it has been referred to rheumatism, and by others to arsenic,[7] with which the phosphorus has been found, in some cases, to be contaminated. Neither of the latter assumed causes, however, are sufficient to account for it. Rheumatic invalids and arsenic-smelters are not liable to disease of this kind.[8] We may, therefore, assume that the phosphoric fumes are the cause of it. Now these consist in part, perhaps, of phosphorus vapour, but chiefly of phosphorus in combination with oxygen. When in high or brilliant combustion (which often occurs in the lucifer match manufactories), phosphorus yields phosphoric acid (PO^5); but, by slow combustion, the chief product is phosphorous acid (PO^3), which becomes converted into phosphoric acid by the absorption of oxygen. According to Dr. von Bibra,[1] hypophosphorous acid is produced by the oxidation of the vapour of phosphorus.

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[1] See an experiment made by Sundelin on himself, *Handb. der Heilmittellehre*, 2e. Bd. S. 213.

[2] *Treatise on Poisons.*

[3] In the *Morning Herald* of June 17, 1840, is a report of an inquest held on the body of a child killed by sucking the phosphoric ends of lucifer matches.

[4] *Dictionnaire de Matière Médicale.*

[5] *Lancet*, Sept. 14, 1844, p. 754.

[6] In this country, the phosphorus jaw-disease does not appear to have been frequently met with. A case is reported in the *Guy's Hospital Reports* for April 1846 to March 1847, p. 163. Two cases have occurred at the London Hospital.

[7] Dupasquier, *Comptes Rendus*, t. xxiii. p. 454, 1846; and *Journ. de Pharmacie*, t. x. 3e sér. p. 284, 1846; also Chevallier, *Comptes Rendus*, t. xxiii. p. 635, 1846.

[8] Roussel (*Comptes Rendus*, t. xxii. p. 292, Feb. 16, 1846) has shown, that the effects of arsenic have nothing in common with those produced by phosphorus.

Strohl,[2] Roussel, and some others, consider the phosphoric acid to be the agent producing the disease; but it is stated[3] that, in phosphorus manufactories, in which the atmosphere is impregnated with phosphoric acid, no disease of the kind is produced; and, therefore, by some the malady is ascribed to a compound having a lower degree of oxidation. Dr. von Bibra refers it to hypophosphorous acid, but lays great stress on the fact that Schönbein's ozone (see *ante*, p. 307,) is formed during the volatilization of phosphorus.

The jaw disease is presumed to be a local malady produced by the direct action of the fumes on the jaw-bone. For toothache and caries of the teeth are said to have existed prior to the affection of the bone; and it is to be inferred, that if the disease were a constitutional one, and due to the absorption of the poison, that probably other bones would also become affected. Moreover, Dr. von Bibra found in his experiments on rabbits, that unless the jaw bone was exposed to the vapours, that the disease was not produced. Dr. Lorinser, on the contrary, thinks that the poison acts through the blood; and states that individuals under its influence have a peculiar sallow, bloated complexion, combined with a dull expression of the eye and gastric derangement.[4] I have myself observed this remarkable appearance of the countenance in the dipper of a congreve match manufactory, whose jaws, however, were quite sound. The best preventives of the phosphorus jaw disease are good ventilation of the rooms of the manufactory, and personal cleanliness. Mr. Hynam, an extensive manufacturer of congreve matches in Princes Street, Finsbury Square, tells me that no case of this malady has ever occurred among his numerous work-people, some of whom have worked there for seven, eight, or even ten years. Their freedom from the disease he ascribes to good ventilation and personal cleanliness. The dippers wear sponges before their mouths; and all the work-people employ a solution of soda[5] for washing their hands.

Another effect of the phosphorus fumes is irritation of the conjunctiva and of the mucous membrane lining the air passages. Bronchial irritation has been especially noticed by the French writers.[6] In this country, catarrhal and pulmonary affections have been ascribed to the action of these fumes.[7]

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[1] *Die Krankheiten der Arbeiter in den Phosphorzündholzfabriken, ins besondere das Leiden der Kieferknochen durch Phosphordämpfe. Vom chemischphysiologischen, medicinischchirurgischen und medicinischpolizeilichen Standpunkte.* Bearbeitet von Dr. Fr. Ernst von Bibra und Dr. L. Geist, mit neun gemalten Kupfertafeln, Erlangen, 1847.

[2] *Gaz. Méd. de Strasbourg*, Nov. 1845; also, *American Journal of the Medical Sciences*, new series, vol. xii. p. 525, Oct. 1846.

[3] *Brit. and For. Med.-Chir. Rev.* April 1848, p. 454.

[4] I have already (see *ante*, p. 226) noticed the unusual quantity of phosphoric acid found by Dr. Letheby in the urine.

[5] The Austrian government, at the suggestion of a commission appointed to inquire into its origin, ordered the girls employed in the lucifer-match manufacture, to wash their mouths well with acidulated water!! (Dr. Balfour, *Northern Journal of Medicine*, vol. iv. p. 286, 1846; and *Lancet*, Aug. 29, 1846.)

[6] See Gendrin, in Roussel's *Mémoire*, before referred to; and Dupasquier, *ante cit.*

[7] *London Medical Gazette*, xxxix. 210; and *Medical Times*, Dec. 18, 1846, p. 224.

Uses.—In this country, phosphorus is rarely employed, and therefore it will be unnecessary to enter minutely into its uses. It has been strongly recommended in those cases attended with great prostration of the vital powers, as in the latter stages of typhus fever, dropsies, &c.; in some chronic diseases of the nervous system (as epilepsy, paralysis, melancholy, mania, amaurosis, &c.) occurring in debilitated subjects. In some of the exanthemata, as measles, it has been administered to promote the re-appearance of the eruption, when this, from some cause, had receded from the skin. In *impotentia virilis* of old and debilitated subjects, in cholera, and in some other maladies, it has also been exhibited. Paillard recommends phosphorus as a caustic, in the place of moxa, than which, he says, it is more convenient and safe.[1]

Administration.—Phosphorus cannot be given with safety in the solid form. It may be administered dissolved in ether, or, still better, in oil.

Antidotes.—In poisoning by phosphorus, large quantities of mild demulcent liquids are to be exhibited, so as to envelop the phosphorus and exclude it from the air contained in the alimentary canal. Magnesia should be given, in order to neutralise the phosphorous and phosphoric acids which may be formed. Parts burned with phosphorus are to be washed with a weak alkaline solution, to remove any adhering acid which might serve to keep up irritation.

1. TINCTURA PHOSPHORI ÆTHEREA; *Tinctura Ætherea cum Phosphoro,* French Codex; *Ethereal Tincture of Phosphorus.*—(Phosphorus 4 parts, Sulphuric Ether 200 parts by weight. Macerate for a month, in a well-stoppered bottle covered with black paper, occasionally shaking. Preserve it in small bottles, well stoppered and covered with black paper).—The quantity of phosphorus dissolved is about 4 grains for each ounce of ether. Dose from 5 to 10 drops. Some objection has been raised to the use of this preparation, on the ground that, by the evaporation of the ether, the phosphorus will be set free in the stomach, and might ignite.

2. OLEUM PHOSPHORATUM, Ph. Borussica; *Phosphorated Oil.*—(Phosphorus dry and cut into small pieces, gr. xij.; Almond Oil, recently prepared, ℥j. Melt the phosphorus in the oil by the aid of warm water: then agitate until it appears to be dissolved).—One ounce of oil dissolves about four grains of phosphorus. Dose from 5 to 10 drops. It should be administered in some mucilaginous liquid, or made into an emulsion. It may be aromatised by a few drops of some essential oil, as of bergamot.

9. ACIDUM PHOSPHORICUM.—PHOSPHORIC ACID.

Formula PO^5. *Equivalent Weight* 72.

History.—Phosphoric acid was first distinguished by Marggraf, in 1740.

This acid is susceptible of three modifications, designated as *metaphosphoric acid* ($a\ PO^5$), *pyrophosphoric acid* ($b\ PO^5$), and *common phosphoric acid* ($c\ PO^5$). The first combines with *one*, the second with *two*, the third with *three* atoms of water or base: hence the first is denominated *monobasic*, the second *bibasic*, the third *tribasic* phosphoric acid. For an admirable account of these modifications we are indebted to Professor Graham.[2]

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[1] *Lond. Med. Gaz.* vol. ii. p. 254.

[2] *Phil. Trans.* for 1833.

NATURAL HISTORY.—Phosphoric acid occurs both in the inorganised and organised kingdoms (see *ante*, pp. 328-9).

All the phosphoric salts of the mineral kingdom contain the common or tribasic phosphoric acid.[1]

PREPARATION.—A watery solution of common or tribasic phosphoric acid ($c\,PO^5$) is the only modification of phosphoric acid employed in medicine.

In the London Pharmacopœia, diluted phosphoric acid (*acidum phosphoricum dilutum*) is ordered to be thus prepared:—

Take of Phosphorus, ℥j.; Nitric Acid, f℥iv.; Distilled Water, f℥x. Add the phosphorus to the nitric acid, mixed with the water, in a glass retort placed in a sand-bath; then apply heat until eight fluidounces are produced [distilled]. Let these be again put into the retort that eight fluidounces may distil, which are to be rejected. Evaporate the remaining liquor in a platinum capsule until only two ounces and six drachms remain. Lastly, add to the acid, when it is cold, as much distilled water as may make it accurately measure twenty-eight fluidounces.

By the mutual action of phosphorus and dilute nitric acid, phosphorous acid (PO^3), as well as phosphoric acid (cPO^5), is produced, while binoxide of nitrogen is evolved. The formation of phosphorous acid may be accounted for by the mutual reaction of three equivalents of nitric acid and three equivalents of phosphorus: $3P + 3NO^5 = 3PO^3 + 3NO^2$. Phosphoric acid is formed by the action of three equivalents of phosphorus on five of nitric acid: $3P + 5NO^5 = 3cPO^5 + 5NO^2$.

MATERIALS.		COMPOSITION.		PRODUCTS.	
5 eq. Nitric Acid......	270	5 eq. *Nitrogen*..	70	5 eq. Binox. Nitrogen..	150
		10 eq. *Oxygen*....	80		
		15 eq. *Oxygen*....	120	3 eq. Phosphoric Acid..	216
3 eq. Phosphorus.....	96	....			
	366				366

If strong nitric acid be employed, instead of the dilute acid ordered in the Pharmacopœia, the reaction is so energetic that explosion and combustion are sometimes the consequence. In such cases, some nitrate of ammonia is usually developed: the ammonia being formed by the union of the nitrogen of the acid with the hydrogen of the water.

By concentrating the solution of phosphorous and phosphoric acid, the phosphorous acid is converted into phosphoric acid by the free nitric acid present: $3PO^3 + 2NO^5 = 3PO^5 + 2NO^2$. The excess of nitric acid is driven off by evaporation.

PROPERTIES.—The aqueous solution of phosphoric acid (*acidum phosphoricum dilutum*, Ph. L.) prepared as above, is a colourless and odourless liquid. It possesses the usual characteristics of an acid; that is, it is sour to the taste, reddens litmus, and neutralizes bases. Its sp. gr., according to the London Pharmacopœia, is 1·064. By evaporation it acquires the consistence of treacle (*hydrated phosphoric acid*); and when exposed to a higher temperature, it loses water and becomes *pyrophosphoric acid* ($2HO, PO^5$). At a dull red heat a further evolution of water takes place, and a compound is formed, called *metaphosphoric acid* (HO, PO^5); this is fusible, and, by cooling, concretes into a transparent solid, called *glacial phosphoric acid*.

Characteristics.—If the common or tribasic phosphoric acid be saturated with an alkali (soda) so as to form a soluble phosphate, it may be distinguished from all other acids by the following characters:—it throws down, with the soluble salts of lime, lead, and baryta, white precipitates (*phosphates*), soluble in nitric acid. If the phosphate of lead ($3PbO, cPO^5$) (thrown down by a soluble salt of lead) be heated in the oxidizing flame of the blowpipe, it yields a colourless and transparent button, which turns opaque and crystalline on cooling. Nitrate of silver yields with the common phosphate a light yellow precipitate (*tribasic phosphate of silver*, $3AgO, cPO^5$), soluble both in nitric acid and ammonia. Sesquichloride of iron added to the solution of alkaline phosphate, causes a white gelatinous precipitate (*perphosphate of iron*) insoluble in acetic acid. Hydrosulphuric acid produces neither change of colour nor precipitate in a solution of phosphoric acid or phosphate.

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[1] Boussingault, *Ann. Chim. Phys.* lv. 185, 1833.

Pyrophosphoric acid causes, with a solution of nitrate of silver, a white precipitate (*pyrophosphate of silver* $= 2AgO, bPO^5$), but with either chloride of barium or solution of albumen no precipitate.

Metaphosphoric acid causes a white precipitate (*metaphosphate of silver* $= AgO, aPO^5$) with nitrate of silver, and also a white precipitate, with chloride of barium and with a solution of albumen.

PURITY.—The following are the qualities of this preparation, as given in the London Pharmacopœia:—

"Chloride of barium or nitrate of silver being added, whatever is thrown down is readily dissolved by nitric acid. Strips of copper and silver are not acted upon by it, nor is it coloured when hydrosulphuric acid is added. Its sp. gr. is 1·064; 42 grs. of [crystallized] carbonate of soda are saturated by 100 grs. of this acid, and nothing is thrown down."

The chloride of barium is to detect *sulphuric* acid: while the nitrate of silver detects *hydrochloric* acid. Should any free *nitric* acid be present, a portion of the copper and silver would be dissolved, with, on the application of heat, the evolution of binoxide of nitrogen; and the solution would yield a dark precipitate with hydrosulphuric acid. Moreover, if the liquid contains nitric acid, it will, by the aid of heat, decolorize a solution of indigo; and when supersaturated with lime, filtered, and evaporated, yield nitrate of lime. If *phosphorous acid* be present, the solution will yield a precipitate of calomel on the addition of excess of bichloride of mercury; and a black precipitate on the addition of protonitrate of mercury. Should the liquid contain *arsenious acid*, a yellow precipitate (*orpiment*, AsS^3) is obtained when sulphuretted hydrogen is transmitted through it. If *arsenic acid* be present, the acid liquid yields, when saturated with sulphuretted hydrogen and preserved in a stoppered bottle for a day or two, a light yellow precipitate (*persulphuret of arsenic*, AsS^5); but if sulphurous acid be added and heat applied, so as to convert the arsenic into arsenious acid, sulphuretted hydrogen produces immediately a yellow precipitate (*orpiment*, AsS^3).

The quantity of carbonate of soda which, according to the Pharmacopœia, the acid is capable of saturating, indicates the per centage strength to be 10·5. The absence of any precipitate, on the addition of carbonate of soda, shows that no phosphate of lime or any other earthy phosphate is present.

COMPOSITION.—Pure anhydrous phosphoric acid is thus composed:—

	Atoms.	*Eq. Wt.*	*Per Cent.*	*Berzelius.*	*Dulong.*	*Davy.*
Phosphorus	1	32	44·44	43·936	44·923	42·6
Oxygen	5	40	55·55	56·064	55·077	57·4
Phosphoric acid	1	72	100·00	100·000	100·000	100·0

Mr. Phillips says, that 100 grains of the diluted acid of the Pharmacopœia saturate 42 grains of [crystallized] carbonate of soda. This indicates its composition to be as follows:—

	By Weight.
Phosphoric Acid	10·5
Water	89·5
Diluted Phosphoric Acid, *Ph. L.*	100·0

PHYSIOLOGICAL EFFECTS. α. *On Vegetables.*—This acid is poisonous to plants.[1]

β. *On Animals.*—Very few experiments have hitherto been made with it on animals. Orfila[2] found that a strong solution of it acted like sulphuric acid. Thrown into the veins of a dog, it coagulated the blood, and killed the animal within ten minutes. Introduced into the stomach, it acted as a powerfully corrosive poison.

γ. *On Man.*—Diluted phosphoric acid produces the usual effects of the diluted mineral acids, and which I have before noticed (p. 170). It is milder, more assimilable, and, therefore, less likely to disagree with the digestive organs than sulphuric acid, with which, in its action, it is usually compared. These qualities it perhaps derives from its being, as Burdach[3] expresses it, "less heterogeneous to the human organism, since it has a considerable share in the composition of it." The same authority also observes, that besides fulfilling the indications of the mineral acids, "it much exalts the excitability when the organism is weak."

Various effects have been ascribed to this acid, which require to be further investigated ere they are admitted. Thus Hecker[4] says, it exerts a special influence over the nervous system, in virtue of which it possesses the power of allaying pain and spasm. Lentin[5] considers it to be endowed with the specific power of influencing surfaces and the bones, whereby it is enabled to ameliorate various morbid conditions of these parts. Sundelin[6] regards it as a stimulant and tonic to the sexual organs.[7] Various effects have been ascribed to it by Herder.[8]

PHOSPHOROUS ACID.—This acid possesses poisonous properties. Wöhler and Frerichs[9] state, that phosphorus agrees with arsenic in its effects on living beings, in the circumstance that its lower oxide (*e. g.* phosphorous acid) is more injurious than the highest (phosphoric acid). Their experiments do not, however, confirm those made by Weigel and Klug in 1844, in which it was observed that phosphorous acid produced inflammatory swellings of the mucous membrane of the stomach, while phosphoric acid did not. The importance of using phosphoric acid free from phosphorous acid is, however, well established.

USES.—Phosphoric acid has been employed in the same cases in which sulphuric and other mineral acids have been used, and under the same regulations. It may be employed for a longer period, without disturbing the digestive functions, than the other agents of this class.

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[1] Gœppert, quoted by Decandolle, *Phys. Végét.*

[2] *Toxicolog. Génér.*

[3] *Arzneimittellehre*, Bd. iii. S. 395, 1809.

[4] *Arzneimittel.* Bd. ii. S. 305.

[5] *Beitrage zur ausüb. Heilk.* Bd. ii. S. 139.

[6] *Heilmittell.* Bd. ii. S. 234.

[7] Dupasquier states, that the workpeople exposed to the phosphoric fumes in lucifer-match manufactories do not appear to experience sexual excitement therefrom.

[8] *Hufeland's Journ.* Bd. ix. St. 3, S. 148.

[9] *Chemical Gazette*, June 15, 1848.

It has been used in certain cases rather on theoretical than practical grounds. Thus its power of dissolving phosphate of lime has led to its employment in those forms of lithiasis attended with phosphatic deposits in the urine (see foot-note at p. 173), in ossification of the arteries and cardiac valves, and in exostosis and other osseous tumors. Lentin used it as a local agent to check caries, from a notion that this disease depends on a deficiency of phosphoric acid in the part affected. Woulff applied it to promote the formation of bone.

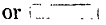
There are several other diseases against which this acid has been administered. Thus it has been given in blenorrhœa and leucorrhœa, when the secreted fluid was thin and acrid (Sundelin),—in profuse suppuration, to diminish the quantity and improve the quality of the secreted matter,—Sundelin has found it useful in hysterical affections of young and irritable subjects,—in impotency of the male (Berends),—in diabetes,—and in jaundice. Dr. Paris[1] has found it to assuage the thirst so commonly present in diabetes, more effectually than any other acidulated drink.

Administration.—Internally, the dilute phosphoric acid should be given in doses of from ten minims to a fluidrachm, properly diluted. Mixed with eight or ten times its volume of water, it may be employed as a wash in caries.

Antidotes.—(See *Sulphuric Acid.*)

Order VI. SULPHUR AND ITS COMPOUNDS WITH OXYGEN, HYDROGEN, AND CARBON.

10. SULPHUR.—SULPHUR OR BRIMSTONE.

Symbol S. *Equivalent Weight* 16. *Equivalent Volume of Sulphur Vapour* 0·16 or 

History.—Sulphur (from *sal*, and πῦρ, *fire*) has been known from the most remote periods of antiquity. It is mentioned by Moses,[2] Homer,[3] and other ancient writers. The word *brimstone* (*brynston*, as written by Piers Ploughman,) signifies *brennestone*, or *burn-stone*.

Natural History.—It is found in both kingdoms of nature.

a. In the Inorganised Kingdom.—*Native* or *virgin sulphur* occurs in two forms: either imbedded in rocks (*common native sulphur*), or produced by sublimation (*volcanic sulphur*). In Sicily[4] it is found in beds in a blue clay formation, which, in the opinion of Dr. Daubeny, is more recent than chalk, but is of the same age with the gypsum beds in the neighbourhood of Paris. Solfatara (called by the ancients *Forum Vulcani*, or the *Court of Vulcan*), a kind of half-extinct volcano, in the vicinity of Naples, is celebrated for its native sulphur, which is collected in considerable quantities for the purpose of commerce.[5] Sulphur is also found in the mineral kingdom in a state of combination. Thus sulphurous acid gas is evolved by volcanoes. Sulphuric acid is found native both in the free and combined states: hydrosulphuric acid gas is evolved from the pure sulphurous or hepatic waters (see p. 298), and from the soil in some other places: lastly, sulphur is found in combination with metals.

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[1] *Appendix to the Eighth Edition of the Pharmacologia*, Lond. 1836.

[2] *Genesis*, xix. 24.

[3] *Iliad*, lib. xvi.

[4] Some mineralogists entertain the opinion, that Sicilian sulphur is of organic (animal) origin.—See *Athenæum* for Dec. 1, 1838; also Leonhard, *Handbuch der Oryktognosie*, S. 599, Heidel. 1826.

[5] Sir W. Hamilton's *Campi Phlegræi*, 1776.

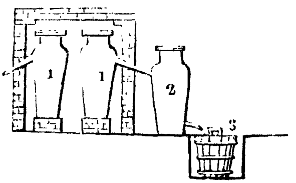
β. IN THE ORGANISED KINGDOM.—Sulphur is found both in animals and plants. Thus it is a constituent of albuminous or protein substances (see *ante*, p. 61), of the allyle oils (see *ante*, p. 220), of cystic oxide (see *ante*, pp. 268-9), &c.

PREPARATION.—Sulphur is procured in two ways: by the purification of native sulphur, or by the decomposition of the native sulphurets. The sulphur of British commerce is almost exclusively obtained in the first way. It is brought principally from Sicily.

a. Purification of native sulphur.—In Sicily, the native sulphur is submitted to a rude process of fusion: it is collected in heaps, which are set fire to on the surface: the heat developed by the combustion of one portion fuses another.[1]

Another mode of extracting sulphur is by distillation in earthen pots in a *furnace gallery*. These are arranged in two rows in a large oblong furnace, fig. 53, (1, 1), the top of each pot, which serves for the introduction of the sulphur and for the removal of the residuum, being kept closed during the operation. The upper and lateral part of each pot communicates with an inclined tube of about two inches diameter and fourteen long. When the fire is lighted in the furnace, the sulphur fuses and sublimes, and passes through this tube into another pot (2), placed on the outside of the furnace, and perforated near its bottom to allow the melted sulphur to flow into a pail (3) containing water, where it congeals, and forms *rough* or *crude sulphur*.[2]

FIG. 53.



Distillation of Native Sulphur.

β. Decomposition of metallic sulphurets.—In some places sulphur is procured by the decomposition of metallic sulphurets (of iron and copper) by heat. This is effected in various ways. At Ramelsberg, and some other places, pyrites are heated or torrefied in pyramidal heaps (*Rösthaufen*) covered by earth. The sulphur is partly burnt and converted into sulphurous acid, and partly volatilized to the summit of the truncated pyramid, where it is condensed in cavities made for the purpose, and from which it is removed from time to time in ladles.[3] Another method consists in roasting the pyrites in chambers or ovens (*Röstöfen*).[4] This is the method adopted at the Parys mine in Anglesea. The copper pyrites are roasted, by which part of the sulphur is burned, while the remainder is volatilized and collected in chambers connected with the domes of the furnaces by means of horizontal flues.[5] A third method, employed in Saxony and Bohemia, consists in submitting pyrites to heat in earthen tubes placed in a furnace gallery. The sulphur is condensed in a receiver containing water.[6] By this process common iron pyrites (FeS^2) is deprived of an atom of sulphur, and the residual sulphuret (FeS), called *Schwefelbrände*, is used for making green vitriol (L. Gmelin).

PROPERTIES OF CRUDE SULPHUR.—Crude or rough sulphur (*sulphur crudum*) is imported into England chiefly from Sicily. Of 507,808 cwt.

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[1] Daubeny, *Description of Volcanoes*, p. 197.

[2] Dumas, *Traité de Chimie*, t. 1er, p. 121.

[3] C. A. Schlüter, *Grundl. Unterricht von Hütte-werken*, Braunschweig. 1738; and Chaptal's *Elements of Chemistry*, vol. i. p. 93, Lond. 1791.

[4] Ferber, quoted by L. Gmelin, i. 600.

[5] Aikin's *Dict. of Chem.* vol. ii. art. *Sulphur*, p. 352.

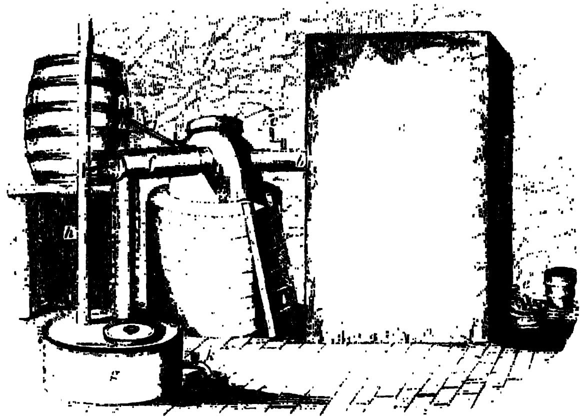
[6] Dumas, *Traité de Chimie*, t. i. p. 132, Paris, 1828.

imported in 1834, 485,756 cwt. came from Sicily (M'Culloch). It comes over in irregular blocks or masses, whose colour is somewhat paler than that of refined sulphur. Fine Sicilian sulphur contains not more than 3 per cent. of foreign matter, chiefly earthy, but not at all arsenical (Ure).

Vauquelin[1] distilled 200 grains of rough sulphur, and obtained a residuum of 0·82, composed of silica, carbonate of lime, iron, bituminous charcoal, alumina, and magnesia; but the proportion of earthy matters is generally more considerable. Sulphur obtained from pyrites usually contains orpiment (AsS^3).

REFINING.—There are three modes of refining sulphur: viz. first, fusion and decantation; secondly, distillation; thirdly, sublimation. Formerly, sulphur was refined by fusing it in an iron cauldron, allowing the earthy impurities to subside, and ladling out the supernatant liquid sulphur. At present, sulphur is refined by distillation and sublimation: by distillation, *massive sulphur* is obtained; by sublimation, *flowers of sulphur*.

FIG. 54.



Distillation of Sulphur.

- *a.* Cast-iron still.
- *b.* Communication between the still and the sulphur chamber (*d*).
- *c.* Handle by which this communication can be shut off.
- *e.* Vent pipe, one end of which opens into the chamber, the other dips into water.
- *f.* Commmunication between the still and the receiver (*g*).
- *h.* Vent pipe.
- *i.* Water butt, which supplies cold water by the pipe *j*, to cool the distilled sulphur, and afterwards runs off at *k*.

For this purpose crude sulphur is put into an iron pot (fig. 54), set in brick work, over a proper fire. To this is adapted an iron head (*a*), removable by a crane, and communicating by two tubes or necks (*b* and *f*), the one with the sulphur chamber (*d*), the other with the iron receiver (*g*), which is immersed in water. The communication (*f*) between the still and the receiver being shut off, the sulphur distils into the sulphur chamber (*d*), on the walls of which it is deposited in a pulverulent form. When obtained in this state, it is called *flowers of sulphur*. The door into this chamber is placed near the ground, and is closed when the process is going on. If the communication (*b*) between the still and the sulphur chamber be shut off by turning the handle (*e*), and the communication (*f*) between the still and the receiver (*g*) opened, the sulphur distils over and condenses into a liquid which, when solidified, constitutes the *refined sulphur* of commerce. The elbow-pipe, which forms the communication between the still and the receiver, is encased in a metal jacket, between which and the tube a current of cold water is continually flowing from the butt (*i*), and, after passing around the receiver (*g*), escapes at *k*. The top of the receiver is perforated by a vent pipe (*h*), and is supplied with a circular aperture, by which the liquid sulphur can be ladled out, but which is usually kept closed by a moveable lid.

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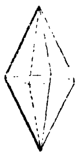
[1] *Ann. de Chim.* xxv. 50.

PROPERTIES.—Refined sulphur occurs in two forms in commerce:—

1st. *Massive*, either in lumps or in sticks. • The former is called *lump sulphur;* the latter, *stick, roll,* or *cane sulphur* (*sulphur in baculis; sulphur in rotulis; sulphur rotundum; sulphur citrinum*).

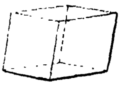
2dly. *Pulverulent,* called *sublimed sulphur* (*sulphur sublimatum*), or *flowers of sulphur* (*flores sulphuris*).

FIG. 55.



Acute rhombic octohedron (the principal form of native sulphur).

FIG 56.



Oblique rhombic prism (principal form of sulphur by fusion and slow cooling).

Solid sulphur may be either crystalline or amorphous. As it is capable of crystallizing in forms belonging to two systems of crystallization, it is said to be dimorphous. Sulphur in acute rhombic octohedrons (fig. 55), belonging to the right prismatic system (see *ante*, p. 141), is found native, and may be also obtained by crystallizing sulphur from its solution in sulphuret of carbon. Sp. gr. 2·0454.

Sulphur in oblique rhombic prisms (fig. 56), belonging to the oblique prismatic system (see *ante*, p. 142), is obtained by fusing it and allowing it to cool slowly. Sp. gr. 1·982.

When sulphur is heated to 340°, it becomes viscid; and, by increasing the heat, the viscidity increases, until the temperature arrives at between 400° and 500°. If, while in this state, it be suddenly cooled, as by throwing it into water, it remains quite soft, so that it may be drawn out into threads. In this state it is called *soft amorphous sulphur*. Its sp. gr. is from 1·957 to 1·961. If it be melted and cooled slowly, it reacquires its crystalline property.

The sulphur of commerce occurs in three prevailing colours; namely, lemon yellow verging on green, dark yellow, and brown yellow: these shades result, partly at least, from the different degrees of heat to which it has been exposed during its fusion or extraction on the large scale, the palest variety having been the least heated (Brande).

Sulphur has a very feeble odour, and scarcely any taste. It is a bad conductor of electricity; and, therefore, by friction becomes powerfully electric. It is a bad conductor of heat; and when grasped in the warm hand, crackles, and sometimes breaks to pieces. It is fusible, volatilizable, and combustible. In atmospheric air, it burns with a pale blue flame, and emits a large quantity of fumes having a peculiar suffocating odour (*sulphurous acid*).

Characteristics.—Sulphur is easily distinguished from other bodies by its fusibility, its volatility, and its burning • with a blue flame, and the evolution of sulphurous acid gas, the odour of which can be easily recognised.—The presence of sulphur, in some metallic sulphurets, may be recognised by the evolution of sulphuretted hydrogen when they are treated with hydrochloric acid. In other sulphurets, the sulphur is detected by the odour of sulphurous acid which they evolve when heated on charcoal before the blow pipe.—In some organic substances (*e. g.* fibrine, albumen, caseine, cystic oxide, &c.) sulphur may be detected by boiling them in a solution of caustic potash to which acetate of lead has been added: sulphuret of lead (known by its dark or black appearance) is obtained.—In some cases, the presence of sulphur is determined by fusing the suspected substance with caustic potash and nitrate of potash, and thereby converting the sulphur into sulphuric acid, which may be detected by the barytic salts (see *Sulphuric Acid*).

PURITY.—Sulphur, when pure, is perfectly volatile; the presence of fixed earthy impurities may, therefore, be detected by volatilizing it.—Pure sulphur is soluble in boiling oil of turpentine, which does not act on the usual impurities of commercial sulphur.—If sulphur contains sulphuret of arsenic, digest in caustic ammonia, which has no action on pure sulphur, but dissolves the arsenical sulphuret; and on supersaturating the solution with hydrochloric acid, a yellow precipitate of arsenical sulphuret is obtained.

PHYSIOLOGICAL EFFECTS. α. *On Vegetables.*—Sulphur does not appear to be injurious to vegetables, for seeds vegetate and produce thriving plants when sown in sulphur.

β. *On Animals.*—At the veterinary school of Lyons it was found that a pound of sulphur killed horses by producing violent inflammation, recognisable during life by the symptoms, and after death by the morbid appearances.[1]

γ. *On Man.*—The general action of sulphur on the system has been already noticed (see *ante*, pp. 93 and 183). On account of its being almost insoluble in the animal juices, its topical action is scarcely more than that of a mechanical irritant. As I have before observed (see *ante*, p. 183), sulphur is probably rendered soluble, and therefore absorbable, by the soda of the bile.

In *small* and *repeated doses*, sulphur acts as a gentle stimulant to the secreting organs, especially to the skin and the mucous membranes, particularly the bronchial membrane. It promotes the capillary circulation of these parts, and increases their secretions. Sundelin[2] says it operates specifically on the mucous membrane of the rectum, and thereby promotes critical hemorrhoidal secretions. That it becomes absorbed is shewn by the odour of hydrosulphuric acid which it communicates to the sweat, urine, and milk, and by silver articles becoming blackened in the pockets of patients who are under the influence of it. By the German physicians it is considered a resolvent. "From mercurial and antimonial medicines," says Sundelin, "sulphur is distinguished by its great diffusibility, in virtue of which it approximates to the exciting tonic agents; and also by its not possessing the liquefacient properties of these agents."

In *larger doses*, as from one to three or four drachms, sulphur acts as a mild purgative, without exciting the pulse or occasioning griping. As the stools are usually solid, Dr. Paris[3] concludes that the action of sulphur on the bowels is confined to the muscular coat. In very large doses, Hartwig has seen it cause gastro-enteritis (Oesterlen).

USES.—Sulphur is employed both internally and externally.

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[1] Christison's *Treatise on Poisons.*

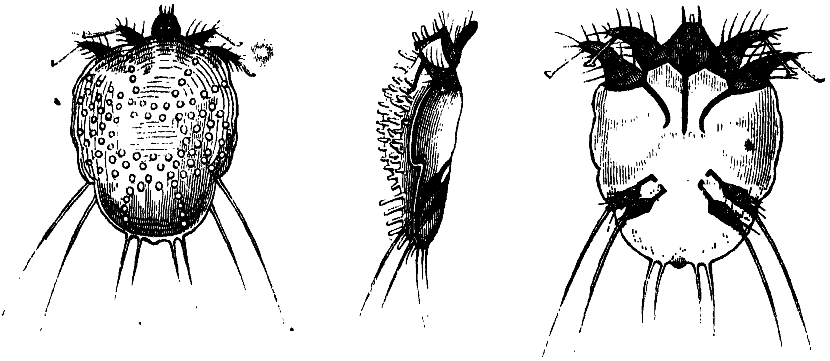
[2] *Heilmittell.* Bd. i. S. 196.

[3] *Pharmacologia*, vol. i. art. *Cathartics.*

α. *Internally.*—It is given for various purposes. *In affections of the rectum,* as stricture, hemorrhoids, and prolapsus, it is a valuable agent as a mild purgative: I have frequently employed it in these cases as a substitute for castor oil. In order to promote its purgative effect, it is sometimes necessary to conjoin magnesia or the bitartrate of potash. *In chronic cutaneous diseases,* more especially prurigo, impetigo, and scabies, the internal use of sulphur is sometimes attended with great benefit. *In pulmonary affections,* as chronic catarrhs and asthma, it is sometimes useful. *In rheumatic and gouty affections* also. After an attack of acute rheumatism, when the joints are left in a swollen and painful state, I have seen sulphur prove highly useful. It is popularly taken with ardent spirit (gin) in this complaint. It has been employed as an *anthelmintic.* Vogt employs it as a *resolvent* in inflammation; as in croup, bronchitis, peripneumonia, and abdominal inflammation. In some constitutional diseases, as scrofula and secondary syphilis, it has been used as an *alterative.* Tortual has proposed sulphur as a preservative against measles; but, as might be expected, experience shews sulphur possesses no prophylactic power of this kind, and that the only preservative is isolation.

β. *Externally.*—Sulphur is a most valuable remedy in various skin diseases, more especially *scabies.* It is supposed by some that its curative power in this disease depends on its poisonous influence over the so-called *itch-insect* (*Sarcoptes Hominis* of Raspail, the *Acarus Scabiei* of other writers): a little parasite belonging to the class *Arachnida* (spiders) of articulated animals, and therefore improperly termed an *insect.*[1]

FIG. 57.



Sarcoptes Hominis—(Raspail.)

But some doubts have been entertained whether this animal be the cause, effect, or mere accompaniment of itch. Rayer[2] observes, that it is indubitable that the number of these insects bears no proportion to that of the vesicles. "It is, further," he adds, "rare to discover these insects on the abdomen and on groins, where the eruption of scabies is nevertheless very common, and very apparent; moreover, scabies is known to continue when no more acari are to be discovered." Sulphur is also a most valuable application in various other skin diseases, as porrigo, impetigo, &c.

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[1] Raspail, *Mémoire sur l'Insecte de la Gale,* Paris, 1834.
[2] *Treatise on Diseases of the Skin,* by Dr. Willis, p. 344.

ADMINISTRATION.—See *Sulphur sublimatum* and *Sulphur præcipitatum*.

1. SULPHUR SUBLIMATUM; *Sublimed Sulphur; Flores Sulphuris* or *Flowers of Sulphur.*—This substance is obtained by sublimation in the way already explained (see *ante*, p. 340).

The Edinburgh College orders it to be thus prepared:—

> "Sublime sulphur in a proper vessel; wash the powder thus obtained with boiling water in successive portions till the water ceases to have an acid taste; then dry the sulphur with a gentle heat."

As usually prepared, sublimed sulphur is apt to be contaminated with a little adhering acid (formed by the oxidation of sulphur), which, in both the Edinburgh and Dublin Pharmacopœias, is ordered to be removed by washing. When thus purified, it is called *washed sulphur* (*sulphur lotum* vel *depuratum*).

The *sulphur lotum* of the Dublin Pharmacopœia is prepared by pouring hot water on sublimed sulphur, and repeating the washing so long as the effused water appears to be contaminated with acid. This is discoverable by means of litmus. The sulphur is then to be dried on bibulous paper.

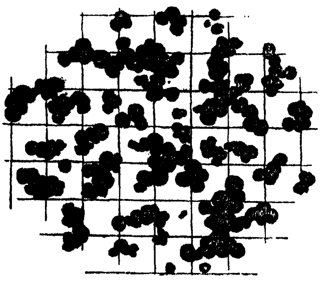
The purity of sublimed sulphur is thus directed to be ascertained by the London College:—

> At a temperature of 600° sublimed sulphur totally evaporates. When washed with water, it does not alter the colour of litmus.

The litmus detects the presence of any free acid (as sulphurous or sulphuric acid).

Sublimed sulphur is a powder of a beautiful greenish yellow colour. It is slightly gritty between the teeth. When examined by the microscope, it is found to consist of smooth almost opaque nodular masses, composed of globules[1] united together while in the liquid state (see fig. 58.) When crushed, they break into irregular fragments. No crystals or traces of crystalline texture are perceptible.[2]

FIG. 58.



Microscopic appearance of sublimed sulphur. (The micrometer squares are equal to those seen in figs. 59 and 60.)

If the vapour of boiling sulphur be received on a glass plate, it condenses in very small transparent viscid globules. If these be kept undisturbed they become opaque, but retain their rounded form. This condition, as well as absence of light, exists in the chamber in which sublimed sulphur is deposited, and, therefore, accounts for the rounded forms and smoothness of the nodules of sublimed sulphur of commerce. If, however, the glass plate be shaken and exposed to light, the globules become converted into crystalline masses, whose surface is uneven from the projecting crystals.

Internally, sublimed sulphur is usually given with syrup or treacle, in the form of an electuary, or suspended in milk. The dose of it, as a purgative, is from one to three or four drachms. As an alterative or sudorific, the dose is about half a drachm.

---

[1] Six globules, including some of the largest and smallest, were carefully measured for me by my friend Mr. Jackson. Their diameters (in parts of an inch) were as follows:—

$0·0012 = \frac{1}{833}$
$0·0008 = \frac{1}{1250}$
$0·0007 = \frac{1}{1428}$
$0·00031 = \frac{1}{3210}$
$0·00028 = \frac{1}{3560}$
$0·00022 = \frac{1}{4540}$

[2] Fritzsche, *Pharm. Central-Blatt. für* 1838, p. 262; also Schweitzer, *Pharm. Journ.* vol. ii. pp. 524-5, 1843.

2. SULPHUR PRÆCIPITATUM; *Precipitated Sulphur; Lac Sulphuris* or *Milk of Sulphur.*—This preparation was known to Geber.[1] It is prepared by boiling together sublimed sulphur, one part; slacked lime, two parts; and water, eight parts. To the filtered solution is to be added a sufficient quantity of hydrochloric acid to precipitate the whole of the sulphur, which is collected and dried in a stove.

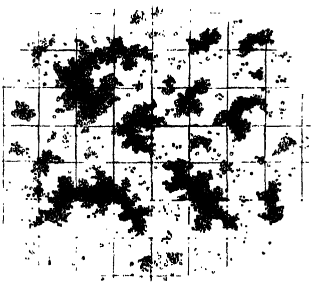
According to L. Gmelin, when sulphur, excess of lime, and water are boiled together, hyposulphite of lime is formed in solution along with a compound either of pentasulphuret of calcium and lime or of pentasulphuret of hydrogen and lime: $13CaO + 12S = 2(5CaO,CaS^5) + CaO,S^2O^2$; or $13CaO + 12S + 2HO = 2\ (6CaO,\ HS^5) + CaO,\ S^2O^2$.

When hydrochloric acid is added to this solution, water, chloride of calcium, and sulphur, are formed: $2\ (5CaO,\ CaS^5) + CaO,\ S^2O^2 + 13HCl = 13HO + 13CaCl + 12S$; or $2\ (6CaO, HS^5) + CaO, S^2O^2 + 13HCl = 13HO + 13CaCl + 12S + 2HO$.

Precipitated sulphur occurs in the form of a fine, soft, dull yellowish powder, with a greyish tint. It differs from sublimed sulphur in its fineness and softness, in its paler yellow colour, in its greyish tint, and its not being gritty between the teeth.

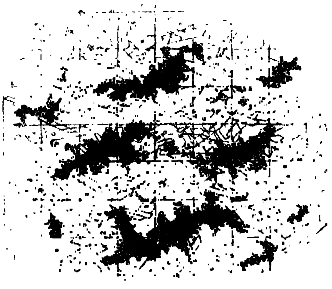
When submitted to microscopic examination, it is found to consist of very minute globules[2] or granules considerably smaller than the globules of sublimed sulphur (see fig. 59). No crystals or crystalline structure are perceptible.

FIG. 59.



Microscopic appearance of pure precipitated sulphur. (The micrometer squares are equal to those seen in figs. 58 and 60.)

FIG. 60.



Microscopic appearance of commercial (i. e. *impure*) *precipitated sulphur, shewing the crystals of sulphate of lime* (*selenite*).

As found in commerce, precipitated sulphur usually contains water; and hence it has been called *hydrate of sulphur*. But both Bucholz and Bischoff have shewn, that when well dried it contains hardly a trace of water; and, therefore, that which, under ordinary circumstances, is contained in it, must be regarded as hygroscopic, so that the term *hydrate* is not applicable to it.

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[1] *Invention of Verity*, chap. vi.

[2] Six of these globules were carefully measured for me by Mr. Jackson: their diameters (in parts of an inch) were as follows:—

$0{\cdot}00042 = \frac{1}{2380}$

$0{\cdot}0004 = \frac{1}{2500}$

$0{\cdot}00035 = \frac{1}{2850}$

$0{\cdot}00016 = \frac{1}{6250}$

$0{\cdot}00007 = \frac{1}{14300}$

$0{\cdot}00006 = \frac{1}{16600}$

Berzelius says, that when melted it gives out a little sulphuretted hydrogen; and on cooling, resumes the yellow colour it had before it was boiled with the alkali. H. Rose[1] ascribes the paleness of precipitated sulphur to the presence of sulphuretted hydrogen, or probably of persulphuret (pentasulphuret) of hydrogen, HS^5.

The precipitated sulphur of commerce is most extensively adulterated with sulphate of lime. In its preparation, sulphuric acid has been substituted for hydrochloric acid, by which the product contains nearly two-thirds of its weight of crystallized sulphate of lime. Mr. Schweitzer[2] analysed a sample, and found its composition to be as follows:—

Sulphate of lime	50·
Water of crystallization of ditto	13·1
Sulphur	36·9
Lac sulphuris of the shops	100·0

This adulterated variety is paler than the pure preparation; and by reflected artificial light it has a glistening or satiny appearance, owing to the presence of the crystals of sulphate of lime. When submitted to microscopic examination it is found to consist of the granules or small globules of precipitated sulphur before mentioned, largely intermixed with crystals (see fig. 60). The adulteration is readily detected by subjecting the suspected preparation to heat in a crucible or on a fire shovel, when the sulphur and water of crystallization are volatilized, leaving behind the anhydrous sulphate of lime. Or the sulphur may be dissolved out by oil of turpentine or liquor potassæ.

The effects, uses, and doses of this preparation, are the same as those of sublimed sulphur.

3. UNGUENTUM SULPHURIS, L. E. D. *Sulphur* or *Brimstone Ointment.* (Sublimed Sulphur, ℥iij. [℥j., *E.*; lb.j., *D.*]; Hog's lard, lbss. [℥iv., *E.*; lbiv., *D.*] Mix them thoroughly together.—(The *London College* adds of Oil of Bergamot, ♏xx.) Extensively employed in scabies, porrigo, and other skin diseases. In scabies, it is to be applied every night until the disease is cured.

4. UNGUENTUM SULPHURIS COMPOSITUM, L. *Compound Sulphur Ointment.*—(Sulphur, lbss.; White Hellebore, powdered, ℥ij.; Nitrate of Potash, ʒj.; Soft Soap,[3] lbss.; Lard, lbjss.; Oil of Bergamot, ♏xxx. Mix.) This is employed in the same cases as the preceding preparation, than which it is considered more efficacious, but at the same time more irritating.

5. OLEUM SULPHURATUM; *Sulphurated Oil; Balsamum Sulphuris,* or *Balsam of Sulphur.* In the London Pharmacopœia for 1824, this compound was ordered to be prepared by dissolving 1 part of Sublimed Sulphur in 8 parts of Olive Oil. The compound thus procured cannot be regarded as a mere solution of sulphur in oil, since the odour of hydrosulphuric acid, which it possesses, proves that the oil has undergone partial decomposition: in fact, the heat to which the oil is raised in order to boil it, causes a chemical change.[4]

It is a dark reddish-brown viscid substance, having an extremely unpleasant odour. Its local action is that of an acrid: its remote operation that of a stimulant, causing thirst and febrile heat. It has been supposed to possess expectorant and diaphoretic properties. It is applied to foul ulcers, and is employed internally in chronic pulmonary affections. The dose of it is from 40 to 50 drops: but its unpleasant taste and smell almost preclude its use.

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[1] Poggendorff's *Annalen*, xlvii.; also *Pharm. Central-Blatt für* 1839, S. 441.

[2] *British Annals of Medicine*, vol. i. p. 618.

[3] For some remarks on the soft soap of the London Pharmacopœia, 1836, used in the above preparation, see the article *Sapo*.

[4] A mixture of equal parts of tallow and sulphur heated in a glass flask yields pure sulphuretted hydrogen (Reinsch, quoted by L. Gmelin).

6. SULPHUR VIVUM:[1] *Horse Brimstone* or *Sulphur Caballinum; Sulphur Griseum; Black Sulphur* or *Sulphur nigrum.*—This is a grey powder composed of sulphur and various impurities. It is the dregs remaining in the subliming pot after the purification of sulphur. When examined by the microscope it is found to differ both from sublimed sulphur and precipitated sulphur, and to consist of irregular broken particles. It has obviously been prepared by grinding. It is popularly supposed to be stronger than sublimed sulphur, and is in common use in various complaints as a substitute for the latter; but its employment is dangerous on account of the occasional presence of arsenic.

II. ACIDUM SULPHURICUM.—SULPHURIC ACID.

Formula SO^3. *Equivalent Weight* 40. *Equivalent Volume of Vapour* 1 or □

HISTORY.—This acid appears to have been known to Geber as early as the seventh century.[2] In the state in which we usually meet with it in English commerce, it is usually denominated *oil of vitriol.* It was formerly called *vitriolic acid* (*acidum vitriolicum*).

NATURAL HISTORY.—It is found in both kingdoms of nature.

FIG. 61.

Cascade of Vinagre in Colombia.

α. IN THE INORGANISED KINGDOM.—It is found in the waters of some volcanic regions, and is evidently produced by the combustion of sulphur. The *Rio Vinagre* (Vinegar River), which descends from the volcano of Puracé in Colombia to Popayan, has received its name from its acid properties, which it derives from being impregnated with sulphuric and hydrochloric acids.[3] Issuing from the crater of Mont Ida, in Java, is a river which also contains this acid.

Dr. Thomas Thomson[4] states, that in Persia there is an earth so strongly impregnated with it, that it is used by the natives as an acidulous seasoner of food.

This author also says,[5] that there are no less than twenty-seven sulphates (consisting of combinations of sulphuric acid with one or more bases) in the mineral kingdom. The most abundant of these is the sulphate of lime. The *sour springs* of Byron, Genesse county, ten miles south of the Erie canal, contain pure sulphuric acid.[6]

β. IN THE ORGANIZED KINGDOM.—The sulphates of lime, potash, and soda, have been found in plants.[1] The sulphates of potash and soda are mentioned by Berzelius[2] as constituents of human urine.

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[1] The *sulphur vivum* or *quick sulphur* of Pliny (xxxv. 50) was dug out of the earth. Pliny says it was transparent and greenish.

[2] Thomson's *Syst. of Inorg. Chem.* vol. ii. p. 29.

[3] A. de Humboldt, *Vues des Cordillères*, p. 220.

[4] *Mineralogy*, vol. i. p. 75.

[5] *Op. cit.* p. 77.

[6] Eaton, *Quarterly Journal of Science*, 1829, p. 200.

MANUFACTURE OF OIL OF VITRIOL.—This subject I shall consider under three heads:—1st, the substances employed; 2dly, the apparatus, or plant used; and 3rdly, the process.

1st. *Substances employed.*—These are eight in number, viz.:—

1st. Sulphur, S; or 2dly, Iron pyrites, FeS^2.
3d. Nitrate of potash, KO, NO^5; or 4thly, Nitrate of soda, NaO, NO^5.
5th. Sulphuric acid of sp. gr. 1·750: HO, SO^3 plus water.
6th. Atmospheric air, consisting of about N^2 and O.
7th. Steam.
8th. Water.

The sulphur employed is that imported from Sicily. To check its combustion, it is sometimes mixed with earthy matter, and made into truncated pyramidal masses, which are burnt in the usual way. For cheapness, pyrites is frequently substituted; but as it is frequently intermixed with arsenical pyrites, the oil of vitriol obtained by it is apt to be contaminated with arsenious acid. The pyrites used for the purpose is procured from the Isle of Sheppey, and various parts of the south and south-eastern coast of England, from Wicklow in Ireland, from the Cornish mines, and even from St. Lucia. The first, on account of its almost entire freedom from arsenic, is the best. The Cornish pyrites is highly arsenical.

The alkaline nitrate is employed to yield nitric acid. The manufacturer's preference of the one nitrate for the other is founded on motives of economy. For every *cwt.* of sulphur burnt about 10lbs. of nitre will be sufficient.

2. *Apparatus* or *plant.* This consists of six parts, viz.:—

1. The sulphur- or pyrites-burner.
2. The nitrate pot.
3. One or more leaden chambers or houses.
4. Leaden concentration pans.
5. Glass or platinum retort.

The sulphur-burner (fig. 62, *b*; and fig. 63, *a*) is a kind of furnace, for the grate of which a stone hearth or iron plate, called the sole, is substituted, on which the sulphur is burnt. The construction of the pyrites-burner is somewhat different, and varies for different kinds of pyrites. It requires to have a fire-grate for the more abundant supply of air. The flue (fig. 63, *f*) of the sulphur or pyrites opens into the leaden chamber.

The nitrate-pot or pan is of cast iron. In it the nitrate is decomposed by the sulphuric acid. It is placed in the burner when required.

The leaden chamber has the form of a parallelopiped. Its size varies according to the work it is required to do. To produce ten tons of oil of vitriol weekly, the chamber should have a capacity of 35,000 cubic feet; or a length of 187 feet, a breadth of 12½ feet, and a height of 15 feet.[3] The bottom of it is covered to the extent of three or four inches with water acidulated with sulphuric acid. Sometimes there is a leaden antechamber to receive and mix the gases before their entrance into the larger chamber. Sometimes the leaden chamber is divided into two or three compartments by leaden curtains placed across it, as shewn in the following cut taken from Professor Graham's *Elements of Chemistry*, vol. i. p. 324.

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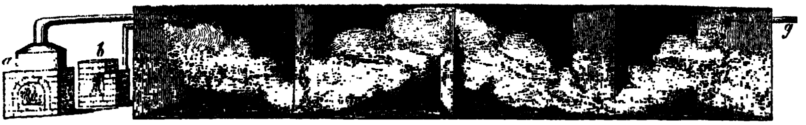
[1] Decandolle, *Phys. Végét.* p. 390.
[2] *Traité de Chim.* t. 7me, p. 393.
[3] *Pharmaceutical Times*, Jan. 2, 1847.

FIG. 62.



Oil of Vitriol Chamber.

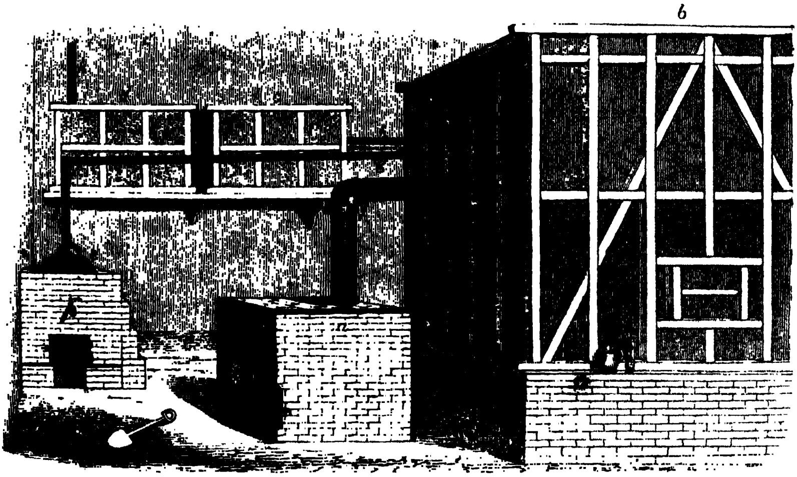
a. Steam boiler.
b. Section of furnace or burner.
d and *f.* Leaden curtains suspended from roof of the chamber to within six inches of the floor.
e. Leaden curtains rising from the floor to within six inches of the roof.
g. Leaden conduit or vent-tube for the discharge of uncondensible gases. It should communicate with a tall chimney to carry off these gases, and to occasion a slight draught through the chamber.

These curtains "serve to detain the vapours, and cause them to advance in a gradual manner through the chamber, so that the sulphuric acid is deposited as completely as possible before the vapours reach the discharge tube."

Sometimes small chambers (see fig. 63, *c*, *d*), also containing water, or long tunnels, are appended to the larger chamber, from which they receive the escaping gases before they are allowed to pass out into the air. These chambers are intended to prevent loss in the process.

In one manufactory which I inspected, the chambers communicated with each other through a double-necked stone bottle, at the bottom of which was water.

FIG. 63.



Oil of Vitriol Manufactory.

a. Sulphur-burner or furnace.
b. First leaden chamber.—In the manufactory from which the above sketch was made, this chamber was 70 feet long, 20 feet wide, and 20 feet high; but the size varies considerably in different establishments.
c. Second } smaller leaden chambers.
d. Third } smaller leaden chambers.
e. Steam boiler.
f. Flue-pipe or chimney of the furnace.
g. Steam pipe.
h. The flue or pipe conveying the residual gas from the first to the second leaden chamber.
i. Pipe conveying the gas not absorbed in the first and second chambers into the third.
k. The flue or waste pipe.
l. Man-hole, by which the workmen enter the chamber when the process is not going on.
m. Pipe for withdrawing a small portion of sulphuric acid from the chamber, in order to ascertain its sp. gr. by the hydrometer.

The flue- or waste-pipe of the leaden chamber serves to carry off the residual nitrogen of the air; but a portion of the binoxide as well as sulphurous acid also escape by it.

The concentration pans are rectangular leaden pans set in brickwork over a fire; plates of iron or tiles, and sometimes a bed of sand, being interposed between the fire and the pan.

The glass or platinum retort is also for the purpose of concentration. Platinum retorts, notwithstanding their great cost, are now usually adopted. Their price of course depends on their size. Mr. Parkes[1] had one which held thirty gallons, and cost about £360; but sometimes they are made so large, that they are worth £1000 each. The platinum is protected from the direct action of the fire by being set in an iron pot.

3. *The process.* The process of the manufacture of oil of vitriol consists of four parts or stages—

1. The oxidation of sulphur and its conversion into sulphurous acid.
2. The oxidation of the sulphurous acid and its conversion into sulphuric acid.
3. The concentration of the dilute sulphuric acid in leaden pans.
4. The final concentration in platinum retorts.

By combustion in the burner, the sulphur combines with atmospheric oxygen, and is converted into sulphurous acid gas: $S+O^2=SO^2$. This passes by the flue-pipe into the leaden chamber. The entrance of air into the burner is regulated by a sliding door.

The nitrate is placed in the nitrate-pot, and mixed with the proper quantity of sulphuric acid sp. gr. 1·750. The pot is then placed on the sole of the burner, so that the flames of the burning sulphur play beneath it. By the mutual action of the acid and the nitrate, an alkaline sulphate is obtained, and nitric acid vapour evolved. This is conveyed by the flue-pipe into the leaden chamber. Assuming nitrate of soda to be employed, the following equation represents the changes which occur in the nitrate pot: $NaO, NO^5+2(HO, SO^3)=NaO,2SO^3+2HO,NO^5$. Part of the nitric acid vapour passes into the leaden chamber in the form of nitrous acid and oxygen.

Steam is conveyed into the leaden chamber from a boiler. It serves at least two purposes: firstly, it causes the intermixture of the sulphurous acid gas and nitric acid vapour; and secondly, it enables these two agents to react on each other.

By the mutual reaction of sulphurous and nitric acid gases, aided by steam, sulphuric acid and nitrous acid are produced. $SO^2+NO^5=SO^3+NO^4$.

MATERIALS.				PRODUCTS.	
1 eq. Nitric Acid	54	1 eq. *Nitrous Acid* ..	46	1 eq. Nitrous Acid ..	46
		1 eq. *Oxygen*	8		
1 eq. Sulphurous Acid	32			1 eq. Sulphuric Acid .	40
	86				86

The condensed steam carrying with it the newly formed sulphuric acid, falls into the acidulated water at the bottom of the leaden chamber.

According to Peligot,[2] the nitrous acid produced by the above reaction is converted by water into nitric and hyponitrous acids. $2NO^4+HO=HO, NO^5+NO^3$. The hyponitrous acid under the influence of more water becomes converted into nitric acid and binoxide of nitrogen. $3NO^3+HO=HO, NO^5+2NO^2$. The binoxide of nitrogen in contact with air absorbs oxygen and is converted into nitrous acid. $NO^2 + O^2 = NO^4$; and this, by the aid of water, is converted into hyponitrous and nitric acids as before.—Thus, according to Peligot, the sulphurous acid acts *incessantly and exclusively* on the nitric acid.

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[1] *Chem. Essays*, vol. i. p. 535.

[2] *Ann. Chim. et Phys.* 3me sér. xii. 1844.

If there be an insufficient supply of steam, a crystalline substance,[1] the bisulphate of the binoxide of nitrogen, is formed, $NO^2, 2SO^3$. When this comes in contact with water it is decomposed, hydrated sulphuric acid is formed, and binoxide of nitrogen gas escapes, causing effervescence: $NO^2, 2SO^3 + 2HO = NO^2 + 2(HO,SO^3)$.

This crystalline substance may readily be formed by conveying sulphurous acid gas into a tall jar, at the bottom of which a small quantity of colourless but concentrated nitric acid is contained. Brown vapours of nitrous acid are evolved, sulphuric acid is formed, and the jar becomes lined with the crystalline matter, which dissolves with effervescence in water.

Attempts have been made to manufacture oil of vitriol without the employment of nitric acid. Mr. Peregrine Phillips has proposed to convert sulphurous acid into sulphuric acid at the expense of the oxygen of the air, by mixing sulphurous acid with an excess of air by a blowing apparatus, and carrying it through a tube filled with platinum sponge, or balls of fine platinum wire (*Graham*). More recently, Schneider[2] has proposed to substitute pumice for spongy platinum; and he states that, by means of it, oil of vitriol of sp. gr. 1·845 can be made without the use either of leaden chambers or platinum retorts.

When the liquid in the leaden chamber has acquired a sp. gr. of about 1·5 (1·6 or 1·7, according to Mr. Farmer's statement to me), it is conveyed by leaden pipes into rectangular leaden boilers, where it is evaporated and concentrated until its sp. gr. is 1·70 (1·75, Farmer); but in some manufactories this part of the process is omitted.

The final concentration is effected in the platinum retort. Here the acid is deprived of a further portion of its water, and acquires a sp. gr. of 1·845; it is drawn off by means of a platinum syphon into carboys. In this part of the process the acid is deprived of some sulphurous acid as well as water.

Old method.—The old method of manufacturing oil of vitriol, and, indeed, one still followed in some places, consists in burning a mixture of eight parts of sulphur and one part of nitrate of potash (or nitrate of soda) on iron or leaden plates, either within the leaden chamber or in a furnace on the outside of it.[3] Fig. 64 is the ground plan of a manufactory of this kind.

In this process, an equivalent of sulphur combines with two equivalents of atmospheric oxygen to form one equivalent of sulphurous acid. Another equivalent of sulphur abstracts three equivalents of oxygen from one equivalent of nitric acid of the nitrate, and thereby becomes sulphuric acid, which, with the potash of the nitre, forms an equivalent of sulphate of potash. One equivalent of binoxide of nitrogen is evolved by the decomposed nitric acid, and this, combining with two equivalents of atmospheric oxygen, becomes nitrous acid, which, aided by the presence of water, is converted into nitric and hyponitrous acids, as before explained. The nitric acid oxidizes the sulphurous acid, and converts it into sulphuric acid.

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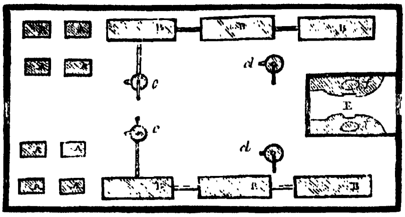
[1] Much difference of opinion has existed with respect to the nature of the crystalline matter which is occasionally formed in the leaden chamber of the sulphuric acid manufacturer. Davy (*Elements of Chemical Philosophy*, p. 276, 1812) regarded it as a compound of *water*, *nitrous acid*, and *sulphurous acid*. Dr. W. Henry (*Annals of Philosophy*, new ser. xi. p. 368), and afterwards Gaultier de Claubry (*Ann. de Chim. et Phys.* t. xlv. p. 284) submitted it to analysis. The latter found its constituents to be *anhydrous sulphuric acid* 65·59, *hyponitrous acid* 23·96, and *water* 10·10. In 1839, Heinrich Rose (*Pharm. Central-Blatt für* 1839, S. 664) described a solid compound of *anhydrous sulphuric acid* and *binoxide of nitrogen*: $2SO^3 + NO^2$. Adolphe Rose (*ibid. für* 1840, S. 481; also *Journ. de Pharm.* t. xxvii. p. 138) has shown, that the crystals which form in the leaden chamber consist of *sulphuric acid*, *binoxide of nitrogen*, and *water*. M. Provostaye (*Journ. de Pharm.* t. xxvi. p. 637) has also examined this crystalline matter.

[2] *Pharmaceutical Journal*, vol. vii. p. 547, 1848.

[3] Parkes's *Chemical Essays*, vol. i. 465.

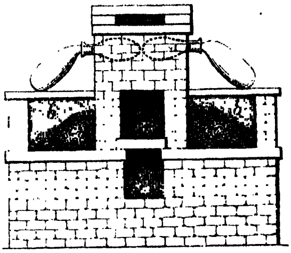
FIG. 64.



Plan of an oil of vitriol manufactory.

A, Rectangular leaden boiler.
B, Leaden chambers.
E, Retort house.
c, Leaden pump for acid.
d, Water pump.

FIG. 65.



Furnace gallery for the distillation of fuming sulphuric acid.

a, The fire-place.
b b, Chamber on each side of the fire-place for depriving the copperas (*c c*) of its water.

MANUFACTURE OF FUMING, SAXONY, OR NORDHAEUSEN SULPHURIC ACID.—At Goslar, Nordhäusen, and other parts of Saxony, sulphuric acid is made thus:—Common sulphate of iron (*copperas* or *green vitriol*) is deprived of its water of crystallization by heat, and then distilled in earthenware, tubular, or pear-shaped retorts contained in a gallery furnace (fig. 65). Some oil of vitriol is put into the earthenware receivers, to condense the dry sulphuric acid which comes over. Sesquioxide of iron (*colcothar* vel *caput mortuum vitrioli*) is left in the retort.

PRODUCTION OF ANHYDROUS SULPHURIC ACID.—By distilling the fuming or Nordhäusen sulphuric acid from a glass retort into a dry and cold receiver, the vapour of the anhydrous acid passes over and concretes in the receiver. $HO,2SO^3 = SO^3 + HO,SO^3$.

PROPERTIES. *a.* **Of Anhydrous Sulphuric Acid.** SO^3.—It is a white crystalline solid, having very much the appearance of asbestos. Exposed to the air it attracts water, and flies off in the form of dense white fumes. It melts at 66° F., and boils at from 104° to 122° F. (125° to 132°·8, Fischer). The sp. gr. of the liquid acid at 78° F. is 1·97. The sp. gr. of its vapour is, according to Mitscherlich, 3·0, but this is probably too high. It does not redden litmus unless moisture be present.

Its composition is as follows:—

	Atoms.	*Eq.Wt.*	*PerCt.*	*Berzelius.*
Sulphur	1	16	40	40·14
Oxygen	3	24	60	59·86
Anhydrous sulphuric acid	1	40	100	100·00

	Vol.	*Sp. Gr.*
Sulphurous acid gas	1	2·2112
Oxygen gas	0·5	0·5528
Sulphuric acid vapour	1	2·7640

β. **Of Nordhaeusen or Fuming Sulphuric Acid.** $HO, 2SO^3$.—This is usually a dark brown (from some organic matter) oily liquid, which gives out copious white fumes in the air. Its sp. gr. is about 1·9. It is imported in stone bottles, having a stoneware screw for a stopper. When subjected to heat, it gives out the vapour of anhydrous sulphuric acid: the residue in the retort resembles oil of vitriol. The composition of fuming sulphuric acid is as follows:—

	Atoms.	*Eq. Wt.*	*Per Ct.*			*Atoms.*	*Eq. Wt.*
Anhydrous sulphuric acid	2	80	89·88	or	Anhydrous sulphuric acid	1	40
Water	1	9	10·11		Protohydrate sulphuric acid	1	49
Fuming sulphuric acid	1	89	99·99			1	89

L. Gmelin says that it is to be regarded as a compound of one atom of water with several atoms of dry sulphuric acid; or of common oil of vitriol with dry acid.

It is often contaminated with sulphurous acid, selenium, earths, oxide of iron, and organic matter. When obtained by putting oil of vitriol into the receiver, as above mentioned, it is of course contaminated with all the impurities contained in the latter.

γ. **Oil of Vitriol, or English Sulphuric Acid.**—This is a colourless, transparent, inodorous, highly acrid, and corrosive liquid. It possesses the usual properties of a powerful mineral acid in a very eminent degree, such as reddening the vegetable blues, saturating bases, and displacing other acids. Its affinity for water is most intense; and by virtue of this, it absorbs aqueous vapour from the atmosphere, and chars animal and vegetable substances. When mixed with water there is a mutual condensation, with the evolution of heat. Various substances when heated in sulphuric acid decompose it; they abstract oxygen and evolve sulphurous acid. This is the case with charcoal, organic substances, phosphorus, sulphur, and several of the metals, as copper, tin, and mercury.

Exclusive of the fuming or Nordhäusen sulphuric acid, there are, according to Graham, three hydrates of sulphuric acid, containing respectively one, two, and three atoms of water to one of dry acid.

1. *Monohydrate of sulphuric acid; oil of vitriol, sp. gr.* 1·845; *Acidum sulphuricum,* L. E. D. HO, SO^3. Dense and colourless, and of an oily consistence. Boils at 620°, and freezes at −29°F. yielding often regular six-sided prisms of a tabular form.

	Atoms.	*Eq. Wt.*	*Per Cent.*
Real sulphuric acid	1	40	81·6
Water	1	9	18·4
Monohydrate of sulphuric acid	1	49	100·0

The British Colleges fix the sp. gr. of the officinal pure sulphuric acid at 1·845.

2. *Binhydrate of sulphuric acid; congelable vitriolic acid; acid of sp. gr.* 1·78 (Graham); sometimes called *Eisöl* (*ice oil*). $2HO, SO^3$. Mr. Graham regards one of the atoms of water as basic, that is, combined as a base with the acid, the other as combined with this sulphate of water. He, therefore, arranges the symbols as follow: $HO, SO^3 + HO$.

In cold weather, acid of this density readily freezes, and produces large, regular, hard crystals, whose form resembles that of carbonate of soda and selenite. Their freezing and melting point is about 45° F.; that is, 13° above the freezing point of water. If the density be either augmented or lessened, the freezing point is lowered.[1] Their sp. gr. is greater than 1·924. In the solid state, this acid has been called *frozen sulphuric acid.* Its composition is as follows:—

	Atoms.	*Eq. Wt.*	*Per Cent.*
Real sulphuric acid	1	40	68·97
Water	2	18	31·03
Binhydrate of sulphuric acid	1	58	100·00

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[1] Keir, *Phil. Trans.* vol. lxxv ii. 1787.

3. *Terhydrate of sulphuric acid; acid of sp. gr.* 1·632 (Graham). $3HO, SO^3$. Mr. Graham regards one of the three atoms of water as basic, and therefore gives the following formula of the acid: $HO, SO^3 + 2HO$. This acid is obtained by evaporating a more dilute acid in vacuo at 212°. It is in the proportions of this hydrate that sulphuric acid and water undergo the greatest condensation, or reduction of volume, in combining.

	Atoms.	*Eq. Wt.*	*Per Cent.*
Real sulphuric acid	1	40	59·7
Water	3	27	40·3
Terhydrate of sulphuric acid	1	67	100·0

The following table, constructed by Dr. Ure,[1] shews the quantity of dry or real acid, and of oil of vitriol, in 100 parts of liquid acid.

Specific Gravity	Per centage		Specific Gravity	Per centage		Specific Gravity	Per centage	
	of Dry Acid.	of Oil of Vitriol.		of Dry Acid.	of Oil of Vitriol.		of Dry Acid.	of Oil of Vitriol.
1.8485	81.54	100	1.5648	54.63	67	1.2490	27.72	34
1.8475	80.72	99	1.5503	53.82	66	1.2409	26.91	33
1.8460	79.90	98	1.5390	53.00	65	1.2334	26.09	32
1.8439	79.09	97	1.5280	52.18	64	1.2260	25.28	31
1.8410	78.28	96	1.5170	51.37	63	1.2184	24.46	30
1.8376	77.46	95	1.5066	50.55	62	1.2108	23.65	29
1.8336	76.65	94	1.4960	49.74	61	1.2032	22.83	28
1.8290	75.83	93	1.4860	48.92	60	1.1956	22.01	27
1.8233	75.02	92	1.4760	48.11	59	1.1876	21.20	26
1.8179	74.20	91	1.4660	47.29	58	1.1792	20.38	25
1.8115	73.39	90	1.4560	46.48	57	1.1706	19.57	24
1.8043	72.57	89	1.4460	45.66	56	1.1626	18.75	23
1.7962	71.75	88	1.4360	44.85	55	1.1549	17.94	22
1.7870	70.94	87	1.4265	44.03	54	1.1480	17.12	21
1.7774	70.12	86	1.4170	43.22	53	1.1410	16.31	20
1.7673	69.31	85	1.4073	42.40	52	1.1330	15.49	19
1.7570	68.49	84	1.3977	41.58	51	1.1246	14.68	18
1.7465	67.68	83	1.3884	40.77	50	1.1165	13.86	17
1.7360	66.86	82	1.3788	39.95	49	1.1090	13.05	16
1.7245	66.05	81	1.3697	39.14	48	1.1019	12.23	15
1.7120	65.23	80	1.3612	38.32	47	1.0953	11.41	14
1.6993	64.42	79	1.3530	37.51	46	1.0887	10.60	13
1.6870	63.60	78	1.3440	36.69	45	1.0809	9.78	12
1.6750	62.78	77	1.3345	35.88	44	1.0743	8.97	11
1.6630	61.97	76	1.3255	35.06	43	1.0682	8.15	10
1.6520	61.15	75	1.3165	34.25	42	1.0614	7.34	9
1.6415	60.34	74	1.3080	33.43	41	1.0544	6.52	8
1.6321	59.52	73	1.2999	32.61	40	1.0477	5.71	7
1.6204	58.71	72	1.2913	31.80	39	1.0405	4.89	6
1.6090	57.89	71	1.2826	30.98	38	1.0336	4.08	5
1.5975	57.08	70	1.2740	30.17	37	1.0268	3.26	4
1.5868	56.26	69	1.2654	29.35	36	1.0206	2.446	3
1.5760	55.45	68	1.2572	28.54	35	1.0140	1.63	2
						1.0074	0.8154	1

Commercial oil of vitriol. (*Acidum sulphuricum venale.*) The oil of vitriol of commerce is seldom so strong as that directed to be kept by the London College: moreover, it is not absolutely pure, being always contaminated with lead, and sometimes with other substances. Mr. Phillips states that its sp. gr. is generally about 1·8433, and then it is constituted very nearly of

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[1] *Journal of Science and Arts*, vol. iv. p. 122, 1818.

	Atoms.	*Eq Wt.*	*Per Cent.*
Real sulphuric acid	1	40	78
Water	1¼	11·25	22
Oil of Vitriol, sp. g. 1·8433	1	51·25	100

The sp. gr. of the commercial sulphuric acid of the Edinburgh Pharmacopœia is fixed at 1·840,—that of the Dublin Pharmacopœia, at 1·850.

Characteristics.—Free sulphuric acid, as well as solutions of the soluble sulphates, yield, with a solution of the chloride of barium, or of nitrate of baryta, a heavy white precipitate (*sulphate of baryta*), insoluble in water and in nitric or hydrochloric acid. If this precipitate be ignited with charcoal, it is decomposed, and converted into sulphuret of barium; which, on the addition of hydrochloric acid, evolves sulphuretted hydrogen, known by its odour, and its blackening paper moistened with solution of acetate of lead.

A solution of a *sulphovinate* or *double sulphate of the oxide of ethyle and a base*, does not yield a precipitate on the addition of a soluble barytic salt; but if the solution be boiled with nitric or hydrochloric acid, the sulphuric acid is set free, and may then be detected by a barytic salt.

Sulphate of baryta is slightly soluble in oil of vitriol; but water precipitates it from its solution.

Selenic acid yields with the barytic salts a white precipitate (*seleniate of baryta*), which is insoluble in nitric acid; but it is soluble in boiling hydrochloric acid, with the disengagement of chlorine and the conversion of the seleniate into a selenite. The seleniate, when ignited with charcoal, does not yield sulphuretted hydrogen on the addition of hydrochloric acid.

Hydrofluosilicic acid yields with the barytic salts a white precipitate, almost insoluble in nitric and hydrochloric acids; but when heated with charcoal, and treated with hydrochloric acid, the precipitate does not evolve sulphuretted hydrogen.

A solution of chloride of barium or of nitrate of baryta, added to concentrated nitric or hydrochloric acid, gives rise to a precipitate (the solid chloride or nitrate), which is soluble in water.

Sulphuric acid and the soluble sulphates produce, with a solution of acetate of lead, a white precipitate (*sulphate of lead*), insoluble in dilute nitric acid, but soluble in hot concentrated hydrochloric acid.

Free sulphuric acid may be distinguished from a sulphate by sugar. Coat a piece of porcelain with a solution of sugar. Then add the sulphuric acid, and heat by steam to dryness: the acid chars the sugar and produces a brown or black spot.

If sulphuric acid be heated with organic matter, sulphurous acid is given out. This may be known by its odour, and by its occasioning the formation of the blue iodide of starch, when mixed with iodic acid and starch. Oil of vitriol reddens veratria, salicin, piperin, oil of bitter almonds, phloridzine, &c.

PURITY.—Commercial oil of vitriol is seldom quite pure. It may contain excess of *water*, by which its sp. gr. is lowered. It then more readily freezes in cold weather. It may contain *hydrochloric acid*, from the use of impure nitrate. Frequently an *oxide of nitrogen* (binoxide, or hyponitrous or nitric acid) is present. *Oxide of lead* combined with sulphuric acid, or sulphate of lead, is usually present. It is derived from the leaden walls of the chambers. *Arsenious acid* is not unfrequently present, when the oil of vitriol has been obtained by the combustion of pyrites. *Organic matters* (from cork, straw, &c.) are often present.

The preceding are by no means infrequent impurities. But, in addition, the presence of several others has been signalised; as *selenium, lime, mag-*

nesia, *titanium*, and the oxides of *zinc*, *tin*, *iron*, *copper*, and *mercury*. Some of them have been found, not in solution, but as a deposit (L. Gmelin).

Commercial acid, when genuine, should never have a sp. gr. greater than 1·8455; when it is denser, we may infer sophistication or negligence in the manufacture (Brande).

According to the *London College*, good oil of vitriol possesses the following characters:—

> It is free from colour. Its specific gravity is 1·845. What remains after the acid has been distilled to dryness, does not exceed the four-hundredth part of its weight. Diluted sulphuric acid is scarcely coloured by hydrosulphuric acid.

The *Edinburgh College* gives the following characters of it:—

> "Density 1810, or near it; colourless; when diluted with its own volume of water only a scanty muddiness arises, and no orange fumes escape."

Oil of vitriol, when pure, is colourless; when it contains organic matter, it is more or less coloured, brownish or black.

Sulphate of lead may be detected by diluting the acid with either water or rectified spirit: in either case the sulphate is separated. The "muddiness" referred to by the Edinburgh College is due to this; as well as the milkiness which the addition of spirit to the acid occasions. If sulphuretted hydrogen be transmitted through the diluted acid, it usually occasions a very slight discolouration only (*sulphuret of lead*).

A solution of the protosulphate of iron detects the binoxide of nitrogen, nitrous acid, or nitric acid, by the reddish brown or brownish black colour which it gives rise to, "if a sufficient quantity of pure sulphuric acid be added to the liquid to be examined" (A. Rose). The solution should be poured over the suspected acid contained in a tube. A reddish, or brownish, or greenish brown colour is produced at the time of contact of the two liquids. Binoxide of nitrogen gives a greenish brown tinge to a solution of the protosulphate of iron. If either nitrous or nitric acid be present, a portion of protoxide is converted into sesquioxide of iron, with the evolution of binoxide of nitrogen, which is absorbed by some of the unaltered protosulphate of iron, to which it communicates a brownish tinge. Permanganate of potash is an excellent test for binoxide of nitrogen or nitrous acid in sulphuric acid diluted with about six parts of water. If either of these substances be present, the permanganate is decolorised. This effect is not produced by the presence of pure nitric acid in diluted sulphuric acid. Hence it distinguishes binoxide of nitrogen and nitrous acid from nitric acid.

Oil of vitriol which has been manufactured from iron pyrites is frequently contaminated with arsenic, mostly as arsenious acid; but sometimes in part also as arsenic acid.[1] Dr. G. O. Rees[2] found 22·58 grains of arsenious acid in twenty fluidounces of oil of vitriol; and Mr. Watson[3] states that the smallest quantity which he has detected is 35½ grs. in twenty fluidounces. I have seen on the sides of the bottle containing arsenical sulphuric acid a deposit of crystallized arsenious acid. If zinc be added to the arsenical sulphuric acid diluted with four or five times its volume of water, hydrogen, mixed with arseniuretted hydrogen, is evolved (see *Arsenious Acid*).

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[1] Wackenroder, *Buchner's Repert.* Bd. xlvii. p. 337, 1834.

[2] *London Medical Gazette* for Feb. 5, 1841.

[3] *Ibid.* for Feb. 1841. Mr. Watson states, that a man had nearly lost his life in consequence of the inhalation of arseniuretted hydrogen, produced in the manufacture of hydrochloric acid, by the diluted, unpurified pyrites, sulphuric acid acting upon the iron retort employed.

Sulphuretted hydrogen transmitted through the diluted arsenical sulphuric acid, converts the arsenious acid, AsO^3, into orpiment, AsS^3, which falls as a yellow precipitate. Very minute quantities of arsenic may be detected by diluting the sulphuric acid with water, supersaturating with carbonate of potash, filtering to separate the deposited sulphate of potash, and washing with a little water, evaporating, supersaturating with hydrochloric acid, and transmitting sulphuretted hydrogen through the liquid (L. Gmelin). If the arsenical sulphuric acid be diluted with water, and accurately saturated with ammonia, it yields, with nitrate of silver, a yellow precipitate, if arsenious acid only be present, but a reddish precipitate if there be also arsenic acid (Wackenroder).

RECTIFICATION.—In order to free the oil of vitriol of commerce from its fixed impurities, it must be subjected to distillation. The acid obtained by this process is called *rectified, distilled, depurated*, or *purified oil of vitriol*. To prepare the *acidum sulphuricum purum*, E. D., the Edinburgh College states that—

"If commercial sulphuric acid contain nitrous acid, heat eight fluidounces of it with between ten and fifteen grains of sugar, at a temperature not quite sufficient to boil the acid, till the dark colour at first produced shall have nearly or altogether disappeared. This process removes nitrous acid. Other impurities may be removed by distillation; which, on the small scale, is easily managed by boiling the acid with a few platinum chips in a glass retort, by means of a sand-bath or gas-flame, rejecting the first half ounce."

The College gives the following characters of the pure acid:—

"Density 1845; colourless; dilution causes no muddiness; solution of sulphate of iron shows no reddening at the line of contact when poured over it."

The *Dublin College* orders of Commercial Sulphuric Acid, lbj. Pass the acid into a retort of flint glass, attach a receiver of the same kind, and with the junctures of the vessels left open, let heat be applied to the retort until one-twelfth part of the liquor shall have distilled over; this, as it contains water, should be rejected. The receiver being again applied, the residuum is to be redistilled to dryness. A few slips of platina passed into the acid in the retort will restrain the ebullition, which otherwise would be too violent. The specific gravity of this acid is to the specific gravity of distilled water as 1845 to 1000. Let this acid be kept in well-closed vessels.

Mere distillation will not produce an absolutely pure sulphuric acid, since the volatile impurities, as nitrous acid, will also pass over. The sugar employed to destroy the latter (nitrous acid), also decomposes a portion of sulphuric acid, and evolves sulphurous acid, which is not entirely removed by the subsequent part of the process.

PHYSIOLOGICAL EFFECTS. α. *On Vegetables.*—In the concentrated state, sulphuric acid chars the parts of plants to which it is applied. In the dilute form, it destroys vegetables in a few hours.[1]

β. *On Animals generally.*—The action of sulphuric acid on animals generally, is precisely the same as that on man. Thrown into the veins of a dog, Orfila found that it coagulated the blood, and caused immediate death.[2]

γ. *On Man.*—Diluted sulphuric acid is a thirst-quenching, refrigerant spanæmic (see *ante*, pp. 170 and 197). It sharpens the appetite, checks profuse sweating, and, not unfrequently, reduces the frequency and volume of the pulse. Under its use, the milk of nurses frequently acquires a griping quality. The effects of the acids on the urine have been already fully discussed (see *ante*, p. 173).

After the use of the acid for a few days, especially if it be exhibited in full doses, patients frequently complain of abdominal pain and griping. If its use be persevered in, these effects augment, heat and pain in the throat and stomach are experienced, the digestive functions are disturbed, and sometimes purging with febrile symptoms occurs.

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[1] Marcet, in De Candolle's *Phys. Végét.* p. 1345.

[2] *Toxicologie Générale.*

The chemical changes presented by the acids in the alimentary canal have been already noticed (see *ante*, p. 171).

The concentrated sulphuric acid is a powerful corrosive or escharotic (see *ante*, p. 157). It abstracts and unites with water and bases contained in the tissues and secretions, coagulates albuminous liquors, combines with albumen, fibrine, and mucus, and darkens the colouring matter of the blood. If its action be carried further it dissolves and decomposes the organic constituents of the tissues, charring or carbonizing them.

The parts to which the acid is applied become, in the first place, white by the formation of sulphate of albumen. This effect is seen both in the cuticle and the cornea. By the more prolonged action of the poison, they assume a brownish or blackish appearance. Black spots are frequently observed in the stomachs of those who have swallowed the acid; and in the surrounding parts the blood is usually coagulated in the blood-vessels. Such are the topical chemical effects of this acid. But besides these there are other phenomena of a local nature which may be denominated vital, since they depend on the reaction of the living parts (see *ante*, p. 91). I refer now to those indicating the production of inflammation in the tissues in the immediate neighbourhood of those destroyed.

When strong sulphuric acid has been swallowed, the symptoms of poisoning are the following:—Alteration, or even destruction, of the soft parts about the mouth; burning pain in the throat, stomach, and bowels; frequently alteration of the voice, from the swelling and disorganization of the parts about the larynx; breath fetid, from the decomposed tissues; constant and abundant vomiting of matters, which may be bloody or otherwise, but which effervesce by falling on a marble hearth; bowels variously affected, sometimes constipated, though usually purged, the stools being bloody. The constitutional symptoms are principally those arising from depression of the vascular system: thus the pulse is frequent and irregular, feeble, often imperceptible; extremities cold; great feebleness, or even fainting, with cold sweats. The same constitutional symptoms are observed when the stomach is wounded or ruptured (see *ante*, p. 114). One remarkable characteristic is, that the mental faculties are usually unaffected, even up to a few minutes before death.

Not unfrequently the acid fails to produce speedy death from corrosion and inflammation, but gives rise to a peculiar organic disease of the stomach and intestines, of which the patient slowly dies, sometimes after several months' suffering.[1]

USES.—Sulphuric acid, properly diluted, may be administered in *febrile diseases*, as a refrigerant, to diminish thirst and preternatural heat; though, in most of these cases, the vegetable acids are to be preferred. In the latter stage of fever considerable benefit is sometimes gained by the use of a vegetable bitter (as calumba or cinchona) in combination with the diluted sulphuric acid. To assist the appetite and promote digestion, it is administered to patients recovering from fever. *To check profuse sweating* in pulmonary and other affections, whether phthisical or not, it is sometimes a valuable agent. No other remedy is so efficacious in relieving colliquative sweatings as this. In *hemorrhages,* as those from the nose, lungs, stomach, and uterus, it is commonly administered as an astringent, but it is obvious that it can only act as such when it can come in contact with the bleeding surface, as where it is administered in hemorrhage from the stomach. In hemorrhage from the nose, lungs, and uterus, its efficacy is, therefore, doubtful. So also in purpura hæmorrhagica it is given with the same intention; but though I have several times employed it, I have not observed any evident benefit derived therefrom. In those forms of *lithiasis* attended with phosphatic sediments in the urine, the mineral acids are resorted to as acid lithics (see *ante,* p. 256); but as I have before explained (see *ante,* pp. 171-173) these acids cannot enter the blood except in combination with bases, and they are eliminated from the kidneys also in combination. If, therefore, they acidify the urine it is only indirectly, and by their action on the digestive and assimilating organs. The sulphuric is preferred to the hydrochloric acid, since it can be continued for a longer period without occasioning gastric disorder. In *skin diseases,* especially lichen, prurigo, and chronic nettle-rash, it is sometimes highly serviceable. No remedy is so successful in relieving the distressing itching, formication, and tingling of the skin, as diluted sulphuric acid taken internally. In those forms of *dyspepsia* connected with an alkaline condition of the stomach, as in pyrosis, the sulphuric has been found to succeed better than hydrochloric acid.[1]

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[1] For further information respecting the topical action of sulphuric acid, the reader may consult (besides Dr. Christison's *Treatise on Poisons*) the observations of Dr. R. D. Thomson, in the *Athenæum* for 1840, pp. 779 and 798; *Lancet* for 1836-7, vol. i. p. 195; and Mr. A. S. Taylor, in *Guy's Hospital Reports*, vol iv., and his work *On Poisons*, Lond. 1848.

As a local agent, sulphuric acid is employed as a caustic, irritant, or astringent. As a caustic it has no advantage over many other agents, except that which arises from its liquid form, which, in most cases, renders it disadvantageous. For example, the difficulty of localizing it would be an objection to its employment in the production of an issue, but would be an advantage in applying it to wounds caused by rabid animals or poisonous serpents, since the liquidity of the acid enables it to penetrate into all parts of the bites. In entropium, or that disease in which the eyelid is inverted, or turned inwards upon the eye, this acid has been applied as a caustic to destroy a portion of the skin, so that by the subsequent cicatrization the lid may be turned outwards. This plan of treatment has been practised successfully by several eminent oculists, among whom I may name Mr. Guthrie and Mr. Lawrence. So also in ectropium, in which the lid is everted or turned outward, Mr. Guthrie has applied the concentrated acid to the inner side of the everted lid with advantage. An ointment containing sulphuric acid has been employed as a rubefacient in paralysis, and in the second stage of inflammation of the joints, when the violence of the disease has subsided; as a styptic to wounds, to suppress hemorrhage from numerous small vessels; and as a cure for scabies. Lastly, this acid, properly diluted, is employed as an astringent gargle in ulcerations of the mouth and throat; but after using it the mouth should be well rinsed, to prevent the action of the acid on the teeth.

ADMINISTRATION.—For internal use we generally make use of the *diluted sulphuric acid,* or the *elixir of vitriol.*

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[1] Dr. R. D. Thomson, *British Annals of Medicine,* March 31, 1837.

ANTIDOTES.—In cases of poisoning by sulphuric acid, the antidotes are chalk, whiting, or magnesia, suspended in water. In the absence of these, soap-suds, infusion of wood-ashes, weak solutions of the alkaline carbonates, white of eggs, gelatine, milk, oil, or in fact any mild diluent, should be immediately administered (see *ante*, p. 160). The subsequent treatment is that for gastro-enteritis. External parts burnt with oil of vitriol should be washed with a solution of soap or simple water.

1. ACIDUM SULPHURICUM DILUTUM, L. E. D. *Diluted Sulphuric Acid; Spirit of Vitriol,* or *Spiritus Vitrioli tenuis; Vitriol to clean Copper.* (Sulphuric Acid, f℥iss. [f℥j. *E.*; one part, *D.*]; Distilled Water, f℥xivss. [f℥xiij., *E.*; seven parts, *D.*] Add the acid to the water gradually, and mix. When the acid and water are mixed, condensation ensues, and heat is evolved).—The white precipitate which forms is sulphate of lead. It is much to be regretted that the formulæ of the British colleges, for the preparation of this acid, should not have been uniform.

According to Mr. Phillips, the sp. gr. of this dilute sulphuric acid, *Ph. Lond.*, is 1·11; and a fluidrachm of it contains nearly 10 grains [9·46 grs.] of strong acid [or about 7·7 grains of real acid], and will saturate 28 grs. of crystallized carbonate of soda. A fluidounce of this acid will, therefore, weigh 485·6 grs.

	By weight.
Anhydrous sulphuric acid	12·73
Water	87·27
Acidum sulphuricum dilutum, *Ph. L.*	100·00

	By weight.
Strongest oil of vitriol	15·6
Water	84·4
Acidum sulphuricum dilutum, *Ph. L.*	100·0

The density of the Edinburgh diluted sulphuric acid is 1·090. The comparative strengths, by weight, of the Edinburgh and London preparations, are as 100 to 78: by volume the difference is still greater.[1] The dose of diluted sulphuric acid is from ♏x. to ♏xxx. or ♏xl., diluted with two or three table-spoonfuls of some mild liquid. A most convenient preparation of it is the compound infusion of roses (*Infusum Rosæ Compositum*). It may also be exhibited in conserve of roses.

2. ACIDUM SULPHURICUM AROMATICUM, E. D. *Aromatic Sulphuric Acid; Elixir of Vitriol,* or *Acid Elixir of Vitriol.*—(The *Edinburgh College* orders of Sulphuric Acid (commercial) f℥iijss; Rectified Spirit, Oiss.; Cinnamon, in moderately fine powder, ℥iss.; Ginger, in moderately fine powder, ℥j. Add the acid gradually to the spirit; let the mixture digest at a very gentle heat for three days in a closed vessel; mix the powders, moisten them with a little of the acid spirit, let the mass rest for twelve hours, and then put it into a percolator, and transmit the rest of the acid spirit. This preparation may also be made by digesting the powders for six days in the acid spirit, and then straining the liquor.)—(The *Dublin College* orders of Rectified Spirit, Oij. [*wine measure*]; Sulphuric Acid, *by weight,* ℥vj. Add the acid to the spirit gradually: digest the mixture in a closed vessel with an inferior heat, for three days; then add of Cinnamon bark, bruised, ℥iss.; Ginger root, bruised, ℥j. Digest the mixture again for six days; and, lastly, filter through paper placed in a glass funnel.)—When oil of vitriol and rectified spirit are digested together, bisulphate of the oxide of ethule, $C^4H^6O^2, 2SO^3 = AeO, SO^3 + HO, SO^3$, (formerly called sulphovinic acid) is produced. The late Dr. Duncan, junior,[1] ascertained "that not a particle of gas is evolved by the mixture of alcohol and sulphuric acid in the proportions indicated." It is employed as an agreeable substitute for the diluted sulphuric acid; and is administered in the same doses. In a case of poisoning by ten drachms of this preparation, the symptoms were those of local irritation, with vomiting and purging of blood. The patient recovered.[2] Its uses are the same as the acid before mentioned. Dose, twenty drops thrice daily.

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[1] Mr. R. Phillips, *London Medical Gazette*, Aug. 3, 1839, p. 689.

3. **UNGUENTUM ACIDI SULPHURICI**, D. *Sulphuric Acid Ointment.*—(Sulphuric Acid, ʒj.; Prepared Hog's Lard, ℥j Mix). The ingredients should be mixed in a glass or earthenware mortar. The precise changes which sulphuric acid effects on lard have not been studied; they are most likely analogous to those effected by the acid on olive oil. The sulphuric acid unites with the oxide of glycerule of the lard to form bisulphate of the oxide of glycerule, $C^6H^7O^5, 2SO^3 + aq.$, and the fatty acids which are in consequence set free unite with some sulphuric acid. This ointment is of a buff colour. It is a powerful stimulant, and has been employed in paralysis, hemorrhages, and scabies, as before mentioned.

12. ACIDUM SULPHUROSUM.—SULPHUROUS ACID.

Formula SO^2. *Equivalent Weight* 32. *Equivalent Volume* 1 or □.

HISTORY.—Homer[3] mentions sulphur fumigations. Stahl, Scheele, and Priestley, were the first to submit this acid to an accurate examination. It has been termed *phlogisticated sulphuric acid*, or *volatile sulphuric acid*.

NATURAL HISTORY.—It escapes from the earth, in a gaseous form, in the neighbourhood of volcanoes.

PREPARATION.—For chemical purposes it is prepared by mixing two parts of copper filings or mercury with three parts of strong sulphuric acid, applying heat, and collecting over mercury. The results are—sulphate of copper or bipersulphate of mercury and water and sulphurous acid, $Cu + 2\ (HO,SO^3) = CuO,SO^3 + 2HO + 2SO^2$.

For medicinal purposes, however, it is rarely, if ever, necessary to procure it in this way. By the combustion of sulphur in atmospheric air this gas is readily obtained; and when we are about to employ it, either as a disinfectant or as a vapour bath, this method is always followed. $S + O^2 = SO^2$.

PROPERTIES. *a. Of the gaseous acid.*—At ordinary temperatures and pressures it is a colourless and transparent gas, and has a remarkable and well-known odour—that of burning brimstone. It is neither combustible nor a supporter of combustion. It reddens litmus and bleaches some colouring matters, especially infusion of roses, but the colour is restored by sulphuric acid. It is irrespirable, and has a sp. gr. of 2·2. It readily dissolves in water: recently boiled water takes up 33 times its volume of this gas.

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[1] *Supplement to the Edinburgh Dispensatory*, p. 175, Edinb. 1829.

[2] *London Medical Gazette*, vol. xxv. p. 944.

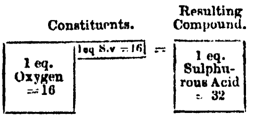
[3] *Iliad*, xvi. 228.

The solution (*aqua acidi sulphurosi*) was formerly called *spirit of sulphur by the bell* (*spiritus sulphuris per campanam*), on account of the method of procuring it.

β. *Of the liquid acid.*—Obtained by subjecting the gaseous acid to the united influence of cold and pressure. It is a limpid liquid, having a sp. gr. of 1·42, Faraday (1·45, Bussy). It boils at 14° F. It dissolves bitumen.

γ. *Of the solid acid.*—Liquid sulphurous acid becomes a crystalline, transparent, colourless body at —105° F.

Characteristics.—This acid is readily known by its peculiar odour—that of burning sulphur. If the puce-coloured or binoxide of lead be added to it, the white protosulphate of lead is formed. An aqueous solution of this acid, mixed with iodic acid, deoxidizes the latter, and sets iodine free, which may be recognised by its producing a blue colour with starch. It decomposes sulphuretted hydrogen, causing the precipitation of sulphur, and reduces solutions of gold. A solution of an alkaline sulphite causes, with a soluble salt of barium, a white precipitate (*sulphite of baryta*). The sulphites evolve sulphurous acid by the action of strong sulphuric acid.



COMPOSITION.—If 16 parts by weight of sulphur be burned in one volume or 16 parts (by weight) of oxygen gas, we obtain one volume or 32 parts (by weight) of sulphurous acid gas.

The composition of this substance may, therefore, be thus expressed:—

	Atoms.	*Eq. Wt.*	*Per Cent.*	*Berzelius.*		*Vol.*
Sulphur	1	16	50	49·968	Sulphur vapour	$\frac{1}{6}$
Oxygen	2	16	50	50·032	Oxygen gas	1
Sulphurous acid	1	32	100	100·000	Sulphurous acid gas	1

PHYSIOLOGICAL EFFECTS. *a. On Vegetables.*—It is a most powerful poison to plants, even in very minute quantities.[1]

β. *On Animals generally.*—The effects on animals have not been examined, but they are probably those of an irritant and asphyxiating agent.

γ. *On Man.*—Applied to the skin, this acid gas causes heat, pain, and itching. If an attempt be made to inhale it in the pure state, it excites spasm of the glottis. (See *ante*, p. 113.) Diluted with air, it may be taken into the lungs, and there acts as a local irritant, causing cough, heat, and pain.

USES.—It has been used as a disinfectant, as a remedy for the cure of itch, and as a nasal stimulant in syncope.

As a *disinfectant* it is mentioned by Homer. The mode of using it for this purpose is very simple. A pot containing burning sulphur is introduced into the room or place to be fumigated, and the doors and windows carefully closed.

As a remedy for itch, baths of sulphurous acid gas are mentioned by Glauber in 1659. They are commonly termed *sulphur baths*, and may be had at most of the bathing establishments of the principal towns of this country. At the Hôpital St.-Louis, in Paris, a very complete apparatus for the application of this remedy in diseases of the skin has been erected by

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[1] Christison, *On Poisons*, 3d edit. p. 750.

D'Arcet.[1] It is a kind of box, inclosing the whole body, with the exception of the head. The sulphur is placed on a heated plate in the lower part of the box. From ten to twenty baths, or even more, are requisite for the cure of itch. "Sulphurous fumigations," says Rayer,[2] "which are employed in some hospitals, are not attended with expense, leave no unpleasant smell, and do not soil the linen; but the long continuance of the treatment necessary to relieve the disease, more than counterbalances these generally insignificant recommendations." There are various other diseases of the skin in which baths of sulphurous acid have been found more or less successful, such as chronic eczema, lepra, psoriasis, impetigo, and pityriasis.[3]

As a stimulant in syncope or asphyxia, this gas has been recommended by Nysten. It is readily applied by holding a burning sulphur match under the nose.

ANTIDOTES.—When sulphurous acid gas has been inhaled, the patient should be made to respire the vapour of ammonia. A few drops of the solution of this substance should be swallowed.

13. Acidum Hydrosulphuricum.—Hydrosulphuric Acid.

Formula HS. *Equivalent Weight* 17. *Equivalent Volume* 1 or □

Sulphuretted hydrogen (*hydrogenium sulphuratum*); *Hydrothion* (*θεῖον, sulphur*); *Hydrothionic acid; Hepatic air* (*äer hepaticus*).—Discovered by Scheele in 1777, though Meyer and Ruellius had previously observed it. It is an ingredient in the sulphurous waters (see *ante*, p. 298); its origin in these cases being probably referable to the action of water or watery acids on metallic sulphurets. In marshy and stagnant waters, and in common waters which have been bottled, it is frequently produced by decomposition of sulphates (especially gypsum) effected by putrescent organic matter (see *ante*, p. 69). Many sulphuretted organic matters evolve it during their decomposition, as eggs, night-soil, &c.

It is usually obtained by the action of dilute sulphuric acid on protosulphuret of iron, $HO,SO^3 + FeS = HS + FeO,SO^3$; or by the action of hydrochloric acid on black sulphuret of antimony, $3HCl + SbS^3 = 3HS + SbCl^3$.

It is a colourless, transparent gas, having the odour of rotten eggs, and a sp. gr. of 1·17. It reddens litmus, and burns in the air with a bluish flame, the deposition of sulphur on the sides of the glass vessel in which it is burned, and the disengagement of sulphurous acid. It blackens white lead and solutions of the salts of lead, copper, and bismuth. When mixed with 20,000 vols. of air, hydrogen, or carburetted hydrogen, its presence may be detected by the discolouration it effects in white lead mixed with water and spread on a card. Under a pressure of 17 atmospheres at 50° F., the gas condenses into a limpid liquid, whose sp. gr. is about 0·9. This liquid freezes at —122° F., and forms a white, crystalline, translucent substance.—Hydrosulphuric acid consists of 16 parts, by weight, of sulphur to 1 of hydrogen.

In chemical investigations, hydrosulphuric acid is important and valuable both as a test and as a separating agent. In toxicological inquiries, therefore, it is in common use (see the article *Arsenious Acid*).

It is a poison to both plants and animals when diffused through the air in which they are placed. Curiously enough, however, the vegetation in the neighbourhood of sulphurous springs is usually luxuriant; so that it would appear to act beneficially when placed within reach of the roots of plants.[1]

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[1] *Description des Appareils à Fumigations établis sur ses Dessins à l'Hôpital Saint-Louis en* 1814, *et successivement dans plusieurs Hôpitaux de Paris, pour le Traitement des Maladies de la Peau*, Paris, 1818.

[2] *Treatise on Diseases of the Skin*, by Dr. Willis, p. 347.

[3] For further information on this subject, consult *Mémoire et Rapports sur les Fumigations Sulfureuses*, par J. C. Galés, 1816; *Observations on Sulphurous Fumigations*, by W. Wallace; *An Essay on Diseases of the Skin*, by Sir A. Clarke.

The respiration of the undiluted gas proves fatal to animals. It becomes absorbed, blackens the blood, and destroys the powers of life. It probably acts as a chemical agent on the blood: Liebig thinks it converts the iron of the blood into a sulphuret. MM. Thénard and Dupuytren state, that air which contains $\frac{1}{1500}$ th of this gas destroys a bird in a very short time: that which contains $\frac{1}{800}$th kills a dog, and that a horse dies in an atmosphere containing $\frac{1}{250}$th part of it. But these statements are probably exaggerated; for rats and other vermin live in large numbers in drains and sewers which are contaminated with this gas: (according to Gaultier de Claubry, these localities contain from two to eight per cent. of it.) On man it acts, when inspired, most injuriously. In the undiluted state it would probably prove fatal. When moderately diluted, its respiration causes immediate insensibility, with depression of all the powers of life. Still more diluted, it causes convulsions; and when air is but slightly contaminated with it, it causes nausea or sickness, debility, and headache. Various ill, or even fatal effects produced by emanations from decomposing organic matters, and which have been loosely ascribed to sulphuretted hydrogen, may be in part owing to other gaseous substances (see *ante*, p. 162) at present undistinguished by their chemical or, in some cases, even by their sensible properties. Parent-Duchâtelet says that workmen can breathe with impunity an atmosphere containing $\frac{1}{100}$th of sulphuretted hydrogen: he himself has respired, without serious symptoms, air containing $\frac{1}{33}$d of it.—It deserves especial notice that this poison is less active when applied to any other part of the body (even, according to Orfila, when introduced into the jugular vein) than when respired. That its activity is very considerably less when introduced into the alimentary canal, must be very obvious when we consider the freedom and impunity with which sulphuretted waters are drank, and the fact that sulphuretted hydrogen is frequently developed in the intestinal tube without any known ill effects. Before its absorption from the alimentary canal, it probably undergoes some chemical change—perhaps forms with the soda of the bile sulphuret of sodium and water (see the article *Sulphurosa*, p. 183).

Sulphuretted hydrogen gas has been employed in medicine; but its use requires great caution. The inhalation of air slightly impregnated with it has been employed to lessen the irritability and excitability of the lungs, in chronic inflammation and phthisical affections of these organs. The benefit which, according to Galen, pulmonary invalids obtained by travelling in Sicily has been ascribed to the presence of sulphur in the atmosphere; and it has been stated that in the neighbourhood of sulphur springs,—those of Aix-la-Chapelle, for example,—phthisis is less prevalent than in other places. Local baths of sulphuretted hydrogen gas, or of aqueous vapour impregnated with this gas, have been employed with benefit in obstinate rheumatic and gouty affections, and chronic cutaneous affections.

As a medicine it is rarely employed except in the form of the sulphurous mineral waters (see *ante*, p. 298). An aqueous solution of it, artificially prepared, is, however, sometimes used.

AQUA ACIDI HYDROSULPHURICI; *Aqua Hydrosulphurata; Acidum Hydrosulphuricum Aquâ Solutum; Sulphuretted Hydrogen Water.*—This is prepared by passing sulphuretted hydrogen gas into cold distilled water until it ceases to be absorbed. Or, better still, by passing sulphuretted hydrogen into a bottle, filled with distilled water, and inverted over the pneumatic trough, until two-thirds of the water are displaced. Then stopper the bottle, and shake that the gas may be absorbed by the water in the bottle. Preserve the solution in a bottle completely filled with it.

At ordinary temperatures and pressures, water absorbs two or three volumes of this gas. The solution has the smell of the gas, and a nauseous, sulphurous taste. By exposure to the air it becomes decomposed; its hydrogen being sweetish, oxidized, and converted into water, and its sulphur precipitated.

This solution is chiefly employed for chemical and toxicological purposes.

The general effects of sulphuretted hydrogen water taken in small doses are those of the *sulphurosa* before mentioned. (See *ante*, p. 183.) It promotes and improves the secretions of the mucous surfaces, the skin, and the glands; and is considered to have a specific influence over the liver and portal system, including the hemorrhoidal vessels.

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[1] Johnston's *Lect. on Agricultural Chemistry*, 2d ed. 1847.

Thus its sensible effects are those of an aperient, expectorant, sudorific, cholagogue, diuretic, and emmenagogue. It is useful in medicine as an alterative and resolvent. Lessmann[1] describes sulphuretted hydrogen as being a stimulant to the vascular system, to the nerves, and to the secreting organs.

Sulphuretted hydrogen water sometimes occasions nausea and vomiting. Taken in large quantities it becomes absorbed, and operates as a narcotic poison, producing effects similar to those caused by its inhalation. It would appear, therefore, that moderate quantities when swallowed undergo a kind of digestion and assimilation (as above alluded to); but that large quantities are absorbed unaltered, and act as a poison.

Sulphuretted hydrogen water has been used as an antidote in poisoning by the salts of lead. Its efficacy consists in its converting the lead salt into a sulphuret of lead. It has also been employed to check mercurial salivation. It is only adapted for maladies of a chronic character, principally cutaneous, rheumatic, gouty, syphilitic, bronchial, hepatic, and hemorrhoidal affections.

When administered as an antidote, it may be given in doses of a wine-glassful, at intervals of from a quarter of an hour to an hour, according to circumstances. In other cases it is given to the extent of from half a wine pint to a pint during the day. A little essence of peppermint may be taken as a corrective. It is sometimes administered with carbonic acid or Selters water.

Externally, sulphuretted hydrogen water has been used as a wash or bath. In general, however, a solution of sulphuret of potassium or of sulphuret of calcium is employed as a substitute. (See *Balneum sulphuratum.*)

Hahnemann's test liquor (*liquor probatorius Hahnemanni*) for detecting the presence of lead in wine is prepared by adding a drachm of tartaric acid to four ounces of sulphuretted hydrogen water. It is, therefore, an acidulated sulphuretted hydrogen water (*aqua hydrosulphurata acidula.*)

14. Carbonii Bisulphuretum.—Bisulphuret of Carbon.

Formula CS^2. *Equivalent Weight* 38. *Equivalent Volume of Vapour* 1 or □

Sulphide of Carbon; Carburet of Sulphur; Alcohol of Sulphur or *Sulphuris Alcohol.*—Discovered in 1796 by Lampadius.[2] It was at first supposed to be a compound of sulphur and carbon. It is obtained by passing the vapour of sulphur over red hot charcoal, and condensing the vapour of the bisulphuret either in a receiver cooled to 32° F., or in ice-cold water.[3] It may also be procured by distilling a mixture of iron pyrites (FeS^2) and charcoal.[4] At ordinary temperatures, sulphur and carbon are without action on each other; but when sulphur vapour comes in contact with glowing carbon, combination takes place, and the bisulphuret of carbon is formed. The product requires to be rectified by redistillation. If it be required free from water, it must be redistilled from chloride of calcium.

Bisulphuret of carbon is a highly refractive, limpid, colourless liquid, whose odour is fetid and somewhat analogous to that of putrid cabbage. It is extremely volatile, and produces intense cold by its evaporation. Its taste is pungent and hot. It is heavier than water, having a sp. gr. of 1·272. It boils at 106° F., and freezes at —60° F. It is very combustible, burning in the air with a pale blue flame, and disengaging sulphurous and carbonic acids. It is insoluble in water, but is soluble in alcohol, ether, the volatile and the fixed oils. It dissolves sulphur, iodine, phosphorus, camphor, and some resins.

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[1] De *Aeris Hydrothionici usu Medico*, Diss. inaug. Med. Berol. 1830.

[2] Lampadius has subsequently described the preparation, properties, and therapeutical applications of this agent, in a monograph entitled *Ueber den Schwefelalkohol*, &c. Freib. 1826.—2te Aufl. Treib. 1833.

[3] Various forms of apparatus have been employed in this process. Several of these are figured in L. Gmelin's *Handbuch*. A convenient apparatus is also described by Wittstein (*Ueber die Darstell. u. Pruf. chem. u. pharm. Prüparate*, Münch. 1845).

[4] Minute quantities of bisulphuret of carbon have been detected in coal gas. The injury sustained by the bindings of books in the libraries of the London Institution and Athenæum Club, appears to be in part referable to the action of an acid compound of sulphur formed by the combustion of coal gas (see *Pharmaceutical Journal*, vol. vi. p. 584). This compound is probably the product of the combustion of the bisulphuret of carbon contained in the gas.

It combines with the basic sulphuret, forming a sulphocarbonate. Thus, when it is mixed with caustic potash, the products are carbonate of potash and the sulphocarbonate of potassium, $3KO + 3CS^2 = KO,CO^2 + 2\ (KS, CS^2)$.

It is characterised by its odour, its sp. gr., its high refractive power, the colour of its flame and the products of its combustion, its insolubility in water, and by the action of iodine on it. $\frac{1}{1000}$th of its weight of iodine dissolves in it, yielding an amethystine or bluish-red solution: $\frac{1}{200}$th part yields a pale rose-red solution.

It consists of 15·79 per cent. of carbon and 84·21 per cent. of sulphur; or 1 atom = 6 of carbon, and 2 atoms = 32 of sulphur.

Its purity is recognised by the following characters:—It should be limpid, colourless, completely volatile (not leaving a residue of sulphur or other solid matters when submitted to evaporation), and not darken white lead (by which the absence of sulphuretted hydrogen is shown).

Bisulphuret of carbon is allied in its action on the system to sulphuric ether. By some it is considered intermediate between ether and ammonia. It is an acrid or local irritant (see *ante*, p. 164), a diffusible stimulant (see *ante*, p. 217), a narcotic or stupefacient (see *ante*, p. 200), and an anæsthetic (see *ante*, p. 203). It agrees with ether, also, in the circumstance that by its evaporation it produces intense cold. It augments the frequency of the heart's action, and acts as a powerful sudorific. Diuretic and emmenagogue effects have also been ascribed to it. If the vapour of it be applied to the shut eye for a minute or two, it generally causes contraction, seldom dilatation, of the pupil.[1]

As a topical remedy, it has been used as a cooling agent, by evaporation, and as a stimulant and resolvent. Internally, it has been employed as a stimulant, analeptic, or restorative (see *ante*, p. 218), as a sudorific, emmenagogue, ecbolic (see *ante*, p. 264), and anæsthetic (see *ante*, p. 203).

Bisulphuret of carbon has been employed as an analeptic or restorative in fainting, hysterical fits, and in asphyxia. In these cases, its vapour, like that of ammonia, is applied to the nose, or, when the patients are able to swallow, a few drops are administered by the stomach every ten minutes. It has also been used to relieve intoxication.

In rheumatic and gouty affections, it has been administered internally as a powerful stimulant and sudorific, and applied externally as a counter-irritant and resolvent.

It has also been employed as a sudorific and alterative in cutaneous affections; as an emmenagogue in amenorrhœa; as an ecbolic in feeble uterine contractions; as a local resolvent in glandular swellings; as a sorbefacient in goître, and in many other cases.[2]

Very recently it has been tried as an anæsthetic by Dr. Simpson.[3] His account of its effects is as follows:—

"It has been stated in various literary journals, that bisulphuret of carbon has lately been used as an anæsthetic agent at Christiana; but no particulars regarding its employment in Norway, have, as far as I know, been yet published.

"I have breathed the vapour of bisulphuret of carbon, and exhibited it to about twenty other individuals, and it is certainly a very rapid and powerful anæsthetic. One or two stated that they found it even more pleasant than chloroform; but in several it produced depressing and disagreeable visions, and was followed for some hours by headache and giddiness, even when given only in small doses. In one instance I exhibited it, with Mr. Miller's permission, to a patient, from whom he removed a tumour of the mamma. It very speedily produced a full anæsthetic effect; but it was difficult to regulate it during the operation. The patient was restless in the latter part of it, but felt nothing. Like several others when under it, her eyes remained wide open. After the operation she was extremely sick, with much and long-continued headache; and, for fifty or sixty hours subsequently, her pulse was high and rapid, without rigor or symptoms of fever.

"I tried its effects in a case of midwifery, in presence of Dr. Weir, Dr. Duncan, Mr. Norris, and a number of the pupils of the Maternity Hospital. It was employed at intervals during three-quarters of an hour. The patient was easily brought under its influence, a few inspirations sufficing for that purpose; but it was found altogether impossible to produce by it the kind of continuous sleep attending the use of chloroform. Its action was so strong, that when given, as a pain threatened or commenced, it immediately affected the power of the uterine contractions, so as often to suspend them; and yet its effects were so transient that the state of anæsthesia had generally passed off within a minute or two afterwards. The patient anxiously asked for it at the commencement of each pain. During its use she was occasionally sick, and vomited several times. Latterly her respiration became rapid, and her pulse rose extremely high. I then changed the inhalation for chloroform, and, under it, the patient slept quietly on for twenty minutes, when the child was born. During these twenty minutes there was no more sickness or vomiting, and the pulse gradually sank down to its natural standard; and a few minutes after the child was expelled, and while the mother still slept, her pulse was counted at 80. Next day the mother and infant were both well, and she has made a good recovery."

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[1] Dr. Turnbull, *London Medical Gazette*, Nov. 5, 1842.

[2] For notices of some of its other uses, the reader is referred to Richter's *Ausführliche Arzneimittellehre*, Bd. iii. S. 464; and Bd. vi. S. 457; Riecke, *Die neueren Arzneimittel.* 2te Aufl. 1840: Dunglison's *New Remedies*, 1843; and Aschenbrenner, *Die neueren Arzneimittel.* Erlangen, 1848.

[3] *Pharmaceutical Journal*, vol. vii. p. 517.

Dr. Snow[1] has tried the effect of its vapour when diffused through air on mice. He says that it does not cause muscular relaxation prior to death; but tremulous convulsions continue till death, which seems to be threatened almost as soon as complete insensibility to external impressions is established. Dr. Snow thinks that a single deep inspiration of air saturated with its vapour, at a summer temperature, would produce instant death.

Bisulphuret of carbon is administered internally in doses varying from two or six, or more, drops taken on sugar; or dissolved in four times its volume of ether or alcohol; or mixed with milk or mucilaginous decoctions.

Externally, it is employed in the form of embrocation or liniment composed of one part bisulphuret and two parts of almond or olive oil, or of alcohol. Sometimes one part of camphor is dissolved in two parts of the bisulphuret, and the solution mixed with four parts of alcohol.

ORDER VII. CHLORINE AND ITS COMBINATIONS WITH HYDROGEN AND SULPHUR.

15. CHLORINIUM.—CHLORINE.

Symbol Cl. *Equivalent Weight* 35·5. *Equivalent Volume* 1 or □

HISTORY.—This gas was discovered by Scheele in 1774, who termed it *dephlogisticated muriatic acid.* Berthollet, in 1785, named it *oxygenated muriatic acid.* Sir H. Davy called it *chlorine* (from (χλωρός, *egren*), on account of its colour.

NATURAL HISTORY.—It is found in both kingdoms of nature.

α. IN THE INORGANISED KINGDOM it exists principally in combination with sodium, either dissolved in the water of the ocean or forming deposits of rock salt. Chlorine also occurs in combination with magnesium, calcium, lead, silver, &c. Free hydrochloric acid is met with in the neighbourhood of volcanoes, and is probably produced by the decomposition of some chloride.

β. IN THE ORGANISED KINGDOM it is found, in combination, in both animals and vegetables. Sprengel[2] says, maritime plants exhale chlorine principally during the night. Hydrochloric acid, in the free state, exists, according to Dr. Prout, in the stomach of animals during the process of digestion.

PREPARATION.—There are several methods of procuring chlorine gas:—

1. *By adding diluted sulphuric acid to a mixture of common salt and binoxide of manganese.*—This is the cheapest and most usual way of preparing it. Mix intimately three parts of dried common salt with two parts

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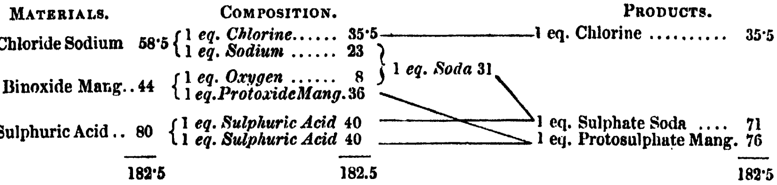
[1] *Lond. Med. Gaz.* June 23d, 1848.

[2] De Candolle, *Physiol. Végét.* tom. i. p. 220.

of the binoxide of manganese, and introduce the mixture into a retort. Then add as much sulphuric acid, previously mixed with its own weight of water, as will form a mixture of the consistence of cream. (Brande directs 8 salt, 3 manganese, 4 water, and 5 acid; Thénard, 1½ salt, 1 manganese, 2 acid, and 2 water; Graham, 8 salt, 6 manganese, and dilute acid as much as contains 13 parts of oil of vitriol.)

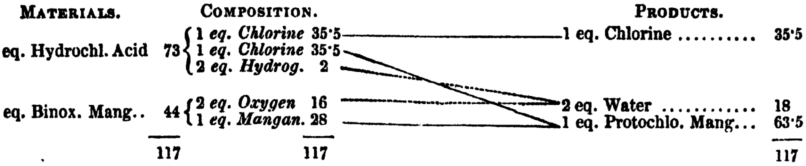
On the application of a gentle heat, the gas is copiously evolved, and may be collected over either warm or cold water.[1]

In this process two equivalents of sulphuric acid react on one equivalent of the binoxide and on one equivalent of chloride of sodium, and yield one equivalent of chlorine, one equivalent of the sulphate of the protoxide of manganese, and one equivalent of sulphate of soda, $MnO^2 + NaCl + 2SO^3 = MnO,SO^3 + NaO,SO^3 + Cl$.



2. *By heating a mixture of equal weights of common hydrochloric acid and binoxide of manganese in a glass retort over a lamp.*

In this process two equivalents of hydrochloric acid react on one equivalent of the binoxide, and yield one equivalent of chlorine, two equivalents of water, and one equivalent of protochloride of manganese, $MnO^2 + 2HCl = MnCl + 2HO + Cl$.



3. *By the action of sulphuric or hydrochloric acid on chloride of lime.*—This method may be resorted to when binoxide of manganese cannot be procured. The products of the reaction of the ingredients are—chlorine, water, and either sulphate of lime or chloride of calcium, according as sulphuric or hydrochloric acid has been employed. When sulphuric acid is employed, the equation is as follows:—$(CaCl + CaO,ClO) + 2SO^3 = 2\ (CaO, SO^3) + 2Cl$.

PROPERTIES. *a. Of gaseous chlorine.*—Chlorine, at ordinary temperatures and pressures, is a gaseous substance, having a yellowish-green colour, a pungent, suffocating odour, and an astringent taste. Its sp. gr., according to Gay-Lussac, is 2·47. It is not combustible, but is a supporter of combustion. Phosphorus and powdered antimony take fire spontaneously when introduced into it; and a taper burns in it, with the evolution of a red light and much smoke. When water is present it destroys vegetable colours, organic odours, and infectious matters. Hence its use as a bleaching agent, a deodorizer, and a disinfectant (see *ante*, p. 162).

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[1] For further information respecting the commercial mode of preparing chlorine, see *Hypochlorite of Lime.*

β. *Of liquid chlorine.*—By a pressure of 4 atmospheres, at the temperature of 60° F., chlorine is a yellow liquid, having a sp. gr. of 1·33 (water being 1·0). Faraday could not freeze it at −166° F.

Characteristics.—The colour and odour of chlorine readily distinguish it from other gases. Free chlorine decolorizes a solution of sulphate of indigo. It forms a white, curdy precipitate (*chloride of silver*) with the nitrate of silver[1]: this precipitate blackens by exposure to light (from the escape of some chlorine and the formation of a subchloride of silver[2]); is insoluble in nitric acid, cold or boiling; readily dissolves in liquid ammonia; when heated in a glass tube, fuses, and, on cooling, concretes into a grey, semi-transparent mass (*horn silver* or *luna cornea*); and lastly, when heated with potash, it yields metallic silver and a chloride of potassium.

Hydrochloric acid and the soluble metallic chlorides, like free chlorine, yield a white precipitate of chloride of silver on the addition of nitrate of silver.

Bromate, bromide, iodate, and iodide of silver, like chloride of silver, are insoluble in dilute nitric acid.

Nitrate of silver does not occasion a precipitate in a solution either of a perchlorate or a chlorate.

Free chlorine bleaches a solution of sulphate of indigo. By this test it may be distinguished both from hydrochloric acid and the chlorides. If, however, hydrochloric acid or a soluble chloride be added to water coloured blue by sulphate of indigo, and the solution be submitted to the action of a galvanic battery, chlorine is evolved at the anode or positive pole, and bleaches the indigo in its immediate neighbourhood.

Hypochlorous acid (ClO) and the alkaline hypochlorites, as also hypochloric acid (ClO^3), possess bleaching properties like chlorine. The odour of these two oxides of chlorine is, however, very different from that of pure chlorine. "Hypochloric acid gas may be distinguished from chlorine, because its bleaching power is not destroyed by a solution of arsenious acid in muriatic acid" (Peligot).

An aqueous solution of chlorine dissolves leaf-gold. The chlorides, when heated with oil of vitriol, evolve hydrochloric acid.

PHYSIOLOGICAL EFFECTS. α. *On Vegetables.*—The germination of seeds has been said to be promoted by watering them with a weak solution of chlorine;[3] but the statement is probably erroneous.

β. *On Animals generally.*—Nysten[4] injected a small quantity of chlorine gas into the jugular vein of a dog, and the only effect was howling. A larger quantity occasioned difficult respiration, apparently great agony, and death in three minutes. The body was opened four minutes afterwards: the blood was fluid and venous in the auricles and ventricles, which contained neither gas nor coagula. On another occasion he threw this gas into the pleura, and thereby produced inflammation of this membrane and death. From these experiments Nysten[1] concludes that it is a local irritant, but has no specific effect on any part of the system.

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[1] Some hypochlorite of silver (which is subsequently converted into chloride and chlorate of silver) is probably also formed.

[2] Wetzlar, in Landgrebe's *Versuch über das Licht*, p. 53, 1834.

[3] De Candolle, *Physiologie Végétale*, t. ii. p. 632.

[4] *Recherches*, p. 140.

γ. *On Man.*—Chlorine gas acts as a *local* irritant. Its chemical agency has been before alluded to (see *ante,* p. 93). Mr. Wallace[2] tells us that diluted with air or aqueous vapour, of 116° F., and applied to the skin, it produces peculiar sensations, similar to those caused by the bite or sting of insects: this effect is accompanied with copious perspiration, and a determination of blood to the skin, sometimes attended with an eruption of minute papulæ, or even vesicles. Applied to the skin in a pure form, its action is similar, but more energetic.

If an attempt be made to inspire undiluted chlorine gas, it produces spasm of the glottis (see *ante,* p. 113). If the gas be mixed with air, it enters into the bronchial ramifications, causes a sensation of tightness and suffocation, and violent cough. Twice I have suffered most severely from the accidental inhalation of it; and each time it gave me the sensation of constriction of the air-tubes, such as might be produced by a spasmodic condition of the muscular fibres of the bronchial tubes. The attack usually goes off in increased secretion from the mucous membrane. When diluted with a large quantity of air, chlorine may be inhaled without exciting cough: it occasions a sensation of warmth in the respiratory passages, and promotes expectoration.

The irritating effects of chlorine are less powerful on those accustomed to inhale it; as I have repeatedly seen in patients who were using the gas, and which is also proved by the following statement, made by Dr. Christison:[3]—"I have been told (says he) by a chemical manufacturer at Belfast, that his workmen can work with impunity in an atmosphere of chlorine, where he himself could not remain above a few minutes."

The constitutional or *remote* effect caused by inhalations of chlorine, is increased frequency of the pulse and of respiration. But this effect may be in part owing to the augmented muscular efforts of the patient. Mr. Wallace states, that the application of chlorine to the skin also occasions soreness of the mouth, fauces, and œsophagus, increased vascularity, and even minute ulcerations of these parts, and an alteration in the quantity and quality of the salivary and biliary secretions. He thinks that it has a tranquillizing, and at the same time exciting, power with respect to the nervous system. It would appear, from the observations of Professor Albers,[4] that though the topical action of chlorine is stimulating, yet the remote action is antiphlogistic; for it diminished the frequency of the pulse, calmed excitement, and produced effects which may be termed antiphlogistic. Dr. Christison tells us, that at the Belfast manufactory above alluded to, the chief consequences of exposure to an atmosphere of chlorine are acidity and other stomach complaints, which the men generally correct by taking chalk. Absorption of fat is also an effect observed in the manufactories at Glasgow, Manchester, and Belfast.[5]

When applied to the skin or bronchial membrane, chlorine gas probably becomes absorbed; for Mr. Wallace found that the urine acquired bleaching properties under its use.

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[1] *Op. cit.* p. 143.

[2] *Researches respecting the Medical Powers of Chlorine, particularly in Diseases of the Liver,* Lond. 1822.

[3] *Treatise on Poisons,* p. 736.

[4] *British and Foreign Medical Review,* vol. iv. p. 212.

[5] *An Experimental Essay on the relative Physiological and Medicinal Properties of Iodine and its Compounds,* by C. Cogswell, A.B. M.D. Edinb. 1837, p. 82.

USES.—*a. As a fumigating agent, disinfectant,* and *antiseptic,* chlorine, I believe, stands unrivalled (*fumigatio chlorinii, oxymuriatica,* seu *Guytoniana*). Hallé, in 1785, appears to have been the first person who employed it as a disinfectant; but we are greatly indebted to Guyton-Morveau for the zeal and energy he manifested in his attempts to introduce it into use. For destroying miasmata, noxious effluvia, and putrid odours, it is the most powerful agent known; and is, therefore, well adapted for disinfecting prisons, ships, hospitals, dissecting-rooms, and all other places, the air of which requires purification. The ingredients for producing the gas should be contained in saucers placed in the higher parts of the room, as the gas which is developed will descend by its density, and soon become mixed with the surrounding air.—The following is the method adopted by Dr. Faraday at the General Penitentiary at Milbank.[1] One part of common salt was intimately mixed with one part of the black or binoxide of manganese, then placed in a shallow earthen pan, and two parts of oil of vitriol, previously diluted with two parts, by measure, of water, poured over it, and the whole stirred with a stick. Chlorine continued to be liberated from this mixture for four days. The quantities of the ingredients consumed were 700 ℔s. of common salt, 700 ℔s. of binoxide of manganese, and 1400 ℔s. of sulphuric acid. The disinfecting power of chlorine is supposed to depend on its affinity for hydrogen, by which it effects the decomposition of water or aqueous vapour, with the hydrogen of which it unites, while the nascent oxygen oxidizes the organic matter: or it may act merely by abstracting hydrogen from the putrid miasmata.

Chlorine fumigations are apparently useless in preventing the progress of cholera and erysipelas. In Moscow, chlorine was extensively tried and found unavailing, nay, apparently injurious, in cholera. "At the time," says Dr. Albers,[2] "that the cholera hospital was filled with clouds of chlorine, then it was that the greatest number of the attendants were attacked."[3] Some years ago chlorine was tried at the Small-Pox Hospital, with a view of arresting the progress of erysipelas: all offensive smell, as usual, was overcome, but the power of communicating the disease remained behind.[4]

β. As an antidote in poisoning by hydrocyanic acid, sulphuretted hydrogen, or hydrosulphate of ammonia, chlorine gas is a very valuable agent. I believe, however, that chloride of lime will be found a more convenient, safe, and opportune substance. The beneficial influence of chlorine in the treatment of animals asphyxiated by sulphuretted hydrogen, doubtless arises, in part at least, from its chemical properties; for when mixed with sulphuretted hydrogen, it forms chloride of sulphur and hydrochloric acid. The best method of applying the remedy is to diffuse a little chlorine in the air, and then to effect artificial respiration (see *ante,* p. 161).

γ. Inhaled in chronic pulmonary diseases.—I have carefully watched its effects in phthisis and chronic bronchitis; and the result of my observation is, that chlorine is rarely serviceable. Frequently, after the first and second inhalations, the patients fancy their breathing much relieved, but the amendment is seldom permanent. I need hardly say it has no pretensions to the cure of tubercular phthisis, but it may be useful as a palliative (sometimes diminishing the sweating); and I can readily believe that occasionally in ulceration of the lungs it may be, as Albers[1] declares it is, of essential service, though I have not found it so. This would agree with effects observed, in surgical practice, of solutions of chlorine and of the hypochlorites on old ulcers.

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[1] *Quarterly Journal of Science and of the Arts,* vol. xviii. p. 92.

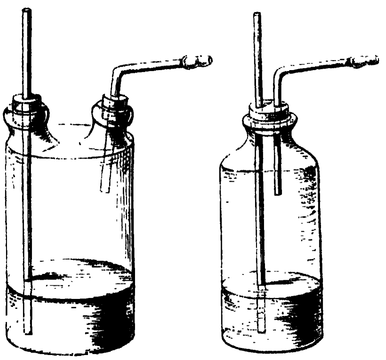
[2] *London Medical Gazette,* vol. viii. p. 410.

[3] See also Dierbach, *Die neust. Entd. in d. Mat. Med.* i. 411, 2te Ausg. 1837.

[4] *London Medical Gazette,* viii. 472.

For inhalation, either the aqueous solution of chlorine, or a small portion of the chloride of lime, may be placed in the inhaling bottles (figs. 66 and 67): if the latter be not sufficiently strong, a few drops of muriatic acid are to be added to develope free chlorine.

Fig. 66. Fig. 67.



Inhaling Bottles.

δ. *In diseases of the liver,* not attended with active inflammation, Mr. Wallace has successfully employed gaseous chlorine, either in the pure state or diluted with air or aqueous vapour. The benefit of chlorine in these cases has been confirmed by others. The temperature of the bath, and the time the patient ought to remain in it, will vary in different instances; but Mr. Wallace thinks that, in the greater number, 150° F. will be found to answer best, and the proper time about half an hour. The benefit obtained is in part referable to the heat employed; in part to the irritant effect of the chlorine on the skin; and (according to Mr. Wallace) in part to the specific influence of chlorine on the liver.[2] Ziese, an apothecary at Altona, has also employed chlorine baths in these cases with advantage.

Antidotes.—The inhalation of ammoniacal gas, of the vapour of warm water, of spirit of wine, or of ether, has been recommended, to relieve the effects of chlorine. I tried them all when suffering myself, but without the least apparent benefit. In a case related by Kastner, and which is reported in Wibmer's work,[3] sulphuretted hydrogen gave great relief. If this agent be employed, it must be done cautiously, as it is itself a powerful poison.

AQUA CHLORINII, Ph. Dub.; *Chlorinei Aqua*, Ph. Ed.; *Chlorine Water.*—*Solutio Chlorinii; Aqua Oxymuriatica; Liquor Chlori; Liquid Oxymuriatic Acid.*—This is readily prepared by passing chlorine gas (prepared as before directed) through water placed in a Woulfe's bottle. The gas may be generated in a clean Florence flask, to which a curved tube is adapted by means of a cork. The receiving vessel holding the water may be, in the absence of a double-necked bottle, a six- or eight-ounce phial; or a wide-mouthed bottle closed by a cork having two perforations, through one of which passes a glass tube open at the top, and dipping into the water beneath; while through the other passes the end of the tube conveying the gas from the flask into the water.

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[1] *British and Foreign Medical Review,* vol. iv. p. 212.

[2] For a sketch of the apparatus used, see *Lancet,* vol. i. for 1831-32, p. 859.

[3] *Die Wirkung der Arzneim. u. Gifte,* 2er Bd. S. 109, München, 1832.

In the *Dublin Pharmacopœia*, the proportions of ingredients used are, Dried Muriate of Soda, 100 parts; Oxide of Manganese, 30 parts; Sulphuric Acid, 87 parts; Water, 124 parts. The gas is to be gradually evolved from this mixture, contained in a retort, and transmitted through 200 parts of Distilled Water.

In the *Edinburgh Pharmacopœia*, the process is somewhat different. Muriate of Soda, 60 grs., and Red Oxide of Lead, 350 grs., are to be triturated together; then put into f℥viij. of Water, contained in a bottle with a glass stopper; afterwards fʒij, of Sulphuric Acid added, and the mixture agitated until all the Red Oxide becomes white. The insoluble matter is to be allowed to subside before using the liquid.

In this process, chlorine and sulphate of soda are formed in solution, and white sulphate of the protoxide of lead is precipitated. The sodium of the common salt is oxidized by the nascent oxygen evolved by the red lead, in consequence of the action of the sulphuric acid on it. This process has been contrived to obviate the necessity of having to pass the gas through water, the apparatus for which operation might not be at hand.

In the *Pharmacopœia Nosocomii Middlesexensis*, Lond. 1841, is the following formula for a solution of chlorine (*solutio chlorinii*):—

℞. Potassæ Chloratis, ʒij.; Acidi Hydrochlorici, Aquæ destillatæ, āā. f℥ij. Misce.

When hydrochloric acid in excess is made to act on chlorate of potash, the products are chloride of potassium, water, and free chlorine, $KO,ClO^5 + 6HCl = KCl + 6HO + 6Cl$.—The solution, as thus prepared, contains chloride of potassium as well as chlorine. It should be kept in a stoppered bottle in a dark place. It is used in the preparation of a mixture and gargle of chlorine.

1. *Mistura Chlorinii.* ℞. Solutionis Chlorinii, Ph. Middlesex., ʒiij.; Aquæ destillatæ, f℥xij. Misce.—This mixture may be flavoured with simple syrup or syrup of orange-peel. Dose, one or two table spoonfuls.
2. *Gargarisma Chlorinii.* ℞. Solutionis Chlorinii, Ph. Middlesex., f℥ij.; Aquæ destillatæ, ℥x. Misce.—Used in scarlet fever, malignant sore throat, &c.

Chlorine combines with water to form a solid crystalline *hydrate*, $10HO,Cl$. This is pale yellow and transparent. When chlorine gas is prepared over water nearly at the freezing point (32° F.), bubbles of gas, in their passage through the water, sometimes become enveloped with a crystalline coating of the hydrate of chlorine.

At the temperature of 60° F., and when the mercury in the barometer is standing at 30 inches, water takes up about twice its bulk of chlorine gas (Gay-Lussac). The solution has a greenish-yellow colour, the strong and peculiar odour of the gas, and an astringent taste. Its sp. gr. is 1·003. At about 32° it freezes and separates into the solid hydrate of chlorine ($10HO,Cl$) and ice free from chlorine. It bleaches vegetable colours, as tincture of litmus, turmeric, &c. By exposure to light, the water is decomposed, oxygen is evolved, and hydrochloric acid formed in solution, $HO + Cl = O + HCl$. Hence the solution should be kept in bottles excluded from the light. Prepared according to the Edinburgh Pharmacopœia, the liquid holds in solution a little sulphate of soda, and deposits a white insoluble sulphate of lead.

Its odour, its action on a solution of nitrate of silver (as before described for chlorine gas), its power of dissolving leaf-gold, and its bleaching properties, readily distinguish this solution. It destroys the blue colour of iodide of starch and of sulphate of indigo. A piece of silver plunged into it is immediately blackened.

In a concentrated form, the aqueous solution of chlorine acts as a corrosive poison. Somewhat diluted, it ceases to be a caustic, but is a powerful local irritant. Administered in proper doses, and sufficiently diluted, it operates as a tonic and stimulant. The continued use of it is said to cause salivation. Applied to dead organic matter, it operates as an antiseptic and disinfectant.

Chlorine water has been employed in medicine both as an external and internal remedy.

Externally it has been used, in the concentrated form, as a caustic application to wounds caused by rabid animals; diluted, it has been employed as a wash in skin diseases (itch and porrigo); as a gargle in putrid sore-throat; as a local bath in liver diseases; and as an application to cancerous and other ulcers attended with a fetid discharge. In the latter cases I have repeatedly employed it with advantage, though I give the preference to a solution of the chloride [hypochlorite] of soda.

Internally it has been administered in those diseases denominated putrid; for example, in the worst forms of typhus, in scarlet fever,[1] and in malignant sore-throat. It has also been employed in venereal maladies, and in diseases of the liver.

The dose of the solution of chlorine varies with the degree of concentration. I have frequently allowed patients to drink, *ad libitum*, water to which some of this solution has been added. If made according to the directions of the Dublin Pharmacopœia, the dose is from one to two drachms properly diluted.

According to Devergie,[2] the antidote for poisoning by a solution of chlorine is albumen. The white of egg, mixed with water or milk (the caseum of which is as effective as the albumen of the egg), is to be given in large quantities. The compound which albumen forms with chlorine has little or no action on the animal economy, and may be readily expelled from the stomach. In the absence of eggs or milk, flour might be exhibited; or if this cannot be procured, magnesia or chalk. The gastro-enteritic symptoms are, of course, to be combated in the usual way.

16. ACIDUM HYDROCHLORICUM.—HYDROCHLORIC ACID.

Formula HCl. *Equivalent Wt.* 36·5. *Equivalent Vol. of the Acid Gas* 2 or

HISTORY.—Watery hydrochloric acid was probably known to Geber, the Arabian chemist, in the 8th century. Basil Valentine described it in the 15th century. The present mode of obtaining it was contrived by Glauber. Priestley, in 1774, first obtained gaseous hydrochloric acid. Scheele, in 1774, may be regarded as the first person who entertained a correct notion of the composition of this acid; and to Sir H. Davy we are principally indebted for the establishment of Scheele's opinion.

The acid was formerly called *marine* or *muriatic acid* (from *muria*, brine or salt water). It is now usually termed, from its composition, *hydrochloric* or *chlorhydric acid*.

NATURAL HISTORY.—It is found in both kingdoms of nature.

a. IN THE INORGANISED KINGDOM.—Hydrochloric acid is one of the gaseous products of volcanoes.

β. IN THE ORGANISED KINGDOM.—Free hydrochloric acid is a constituent of the gastric juice in the human subject (?). Chevreul states that he detected free hydrochloric acid in the juice of *Isatis tinctoria*.

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[1] See a paper *On the Use of Chlorine in Scarlatina*, by Messrs. Taynton and Williams, in *Lond. Med. Gaz.* vol. iv. p. 432. [The authors speak of "the chlorine." Is not a chloride (hypochlorite) meant?]

[2] *Médecine Légale*, t. ii. p. 634, Paris, 1836.

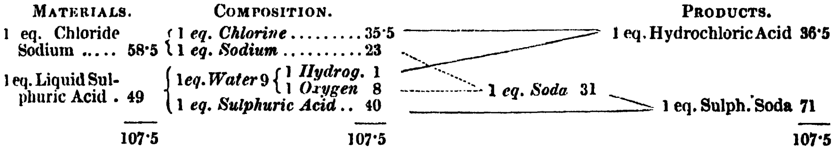
FORMS.—Hydrochloric acid is used in two forms; in the gaseous state (*gaseous hydrochloric acid*), and dissolved in water (*watery hydrochloric acid*).

1. Gaseous Hydrochloric Acid.

SYNONYMES.—*Muriatic acid gas; hydrochloric acid gas; chlorhydric acid gas.*

PREPARATION.—Hydrochloric acid, in the gaseous state, is procured by the action of oil of vitriol on dried chloride of sodium. The ingredients should be introduced into a tubulated retort, the neck of which is lined with bibulous paper, and the gas collected over mercury. Or they may be placed in a clean and dry oil flask, and the gas conveyed, by means of a glass tube curved twice at right angles, into a proper receptacle, as a bottle, from which the gas expels the air by its greater gravity.

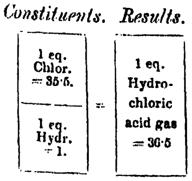
In this process, one equivalent of chloride of sodium reacts on one equivalent of protohydrate of sulphuric acid (strong oil of vitriol), and produces one equivalent of hydrochloric acid (gas), and one equivalent of sulphate of soda. $NaCl + HO,SO^3 = NaO,SO^3 + HCl$.


MATERIALS.
COMPOSITION.
PRODUCTS.
1 eq. Chloride Sodium ..... 58·5
1 eq. Chlorine ....35·5
1 eq. Sodium 23
1 eq. Hydrochloric Acid 36·5
1 eq. Liquid Sulphuric Acid . 49
1 eq. Water 9
1 Hydrog. 1
1 Oxygen 8
1 eq. Sulphuric Acid .. 40
1 eq. Soda 31
1 eq. Sulph. Soda 71
107·5
107·5
107·5

PROPERTIES.—It is a colourless invisible gas, fuming in the air, in consequence of its affinity for aqueous vapour. It is rapidly absorbed by water. At 40° F., water dissolves about 480 times its bulk of this gas. Its specific gravity is 1·264 [1·269 Berzelius]. It has a pungent odour and acid taste. Under a pressure of 40 atmospheres, at 50° F., it becomes a colourless liquid (*liquid hydrochloric acid*). It is neither combustible nor a supporter of combustion. When added to a base (that is, a metallic oxide), water and a chloride are the results. $HCl + MO = HO + MCl$.

Characteristics.—Hydrochloric acid gas is known by its fuming in the air, by its odour, by its reddening moistened litmus paper, by its forming white fumes with the vapour of ammonia, and by its yielding, with a solution of nitrate of silver, a white precipitate of chloride of silver (see *ante*, p. 369).

COMPOSITION.—The composition of this gas is determined both by analysis and synthesis. Thus, one volume of chlorine gas may be made to combine with one volume of hydrogen gas by the aid of light, heat, or electricity; and the resulting compound consists of two volumes of hydrochloric acid gas. Potassium or zinc heated in two volumes of this acid gas, absorbs the chlorine and leaves a volume of hydrogen.



	Atoms.	*Eq.Wt.*	*Per Ct.*		*Vol.*	*Sp. Gr.*
Chlorine	1	35·5	97·33	Chlorine gas	1	2·46
Hydrogen	1	1	2·66	Hydrogen gas	1	0·069
Hydrochloric Acid	1	36·5	100·000	Hydrochloric Acid gas	1	1·264

PHYSIOLOGICAL EFFECTS. *α. On Vegetables.*—Mixed with 20,000 times its volume of atmospheric air, this gas is said, by Drs. Christison and Turner,[1] to have proved fatal to plants, shrivelling and killing all the leaves in twenty-four hours. But, according to Messrs. Rogerson,[2] it is not injurious to vegetables when mixed with 1500 times its volume of air. Dr. Christison ascribes these different results to Messrs. Rogerson having employed jars of too small size. We have good evidence of the poisonous operation of this gas on vegetables in the neighbourhood of those chemical manufactories in which carbonate of soda is procured from common salt. The fumes of the acid which issue from these works have proved so destructive to the surrounding vegetation, that, in some instances, the proprietors have subjected themselves to actions at law, and have been compelled either to pay damages, or to purchase the land in their immediate vicinity.

β. On Animals this gas acts injuriously, even when mixed with 1500 times its volume of atmospheric air. Mice or birds introduced into the pure gas, struggle, gasp, and die, within two or three minutes. Diluted with atmospheric air, the effects are of course milder, and in a ratio to the quantity of air present. In horses it excites cough and difficulty of breathing. When animals are confined in the dilute gas, in addition to the laborious and quickened respiration, convulsions occur before death. Messrs. Rogerson state, that "in a legal suit for a general nuisance, tried at the Kirkdale Sessions House, Liverpool, it was proved that horses, cattle, and men, in passing an alkali-works, were made, by inhaling this gas, to cough, and to have their breathing much affected. In the case of Whitehouse *v.* Stevenson, for a special nuisance, lately tried at the Staffordshire Assizes, it was proved that the muriatic acid gas from a soap manufactory destroyed vegetation, and that passengers were seized with a violent sneezing, coughing, and occasional vomiting. One witness stated, that when he was driving a plough, and saw the fog, he was obliged to let the horses loose, when they would gallop away till they got clear of it." It acts as an irritant on all the mucous membranes.

γ. On Man this gas acts as an irritant poison, causing difficult respiration, cough, and sense of suffocation. In Mr. Rogerson's case, it caused also swelling and inflammation of the throat. Both in man and animals it has appeared to produce sleep.

The action of hydrochloric acid gas on the lungs is injurious in at least two ways: by excluding atmospheric air, it prevents the decarbonization of the blood; and, secondly, by its irritant, and perhaps also by its chemical properties, it alters the physical condition of the bronchial membrane. The first effect of attempting to inspire the pure gas seems to be a spasmodic closure of the glottis (see *ante*, p. 113). Applied to the conjunctiva, it causes irritation and opacity.

USE.—It has been employed as a *disinfectant* (see *ante*, p. 162), but is admitted on all hands to be much inferior to chlorine. The Messrs. Rogerson deny that it possesses any disinfecting property. It is perhaps equally difficult either to prove or disprove its powers in this respect. The experiments of Guyton-Morveau, in purifying the cathedral of Dijon, in 1773, are usually referred to in proof of its disinfecting property. If it possess powers of this kind, they are certainly inferior to chlorine, or the chlorides [hypochlorites] of lime or soda; but, in the absence of these, hydrochloric acid gas may be tried. In neutralizing the vapour of ammonia it is certainly powerful.

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[1] Christison's *Treatise on Poisons.*

[2] *London Medical Gazette*, vol. x. p. 312.

APPLICATION.—In order to fumigate a room, building, or vessel, with this gas, pour some strong oil of vitriol over dried common salt, contained in a saucer or iron or earthen pot, heated by a charcoal fire or hot sand. The saucers should be placed in the higher parts of the chamber, so that the gas may descend by its gravity.

ANTIDOTE.—Inhaling the vapour of ammonia may be serviceable in neutralizing hydrochloric acid gas. Symptoms of bronchial inflammation are of course to be treated in the usual way.

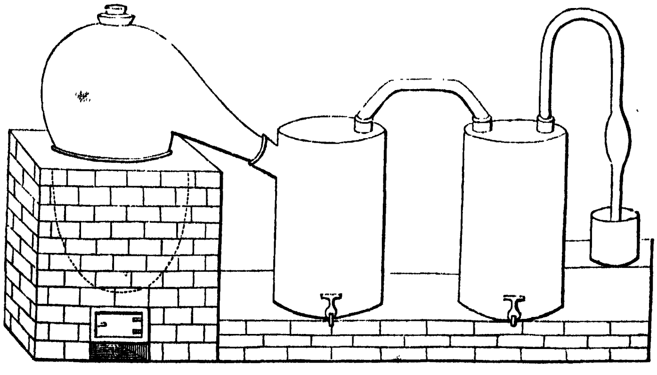
2. Watery Hydrochloric Acid.

SYNONYMES.—This watery or liquid acid was formerly called *spirit of salt* (*spiritus salis*), or *spirit of sea salt* (*spiritus salis marini*), or *Glauber's spirit of salt* (*spiritus salis marini Glauberi*).

It is now commonly termed *muriatic acid* (*acidum muriaticum*, Ph. Ed. and Dub.); or *hydrochloric acid* (Ph. Ed.; *acidum hydrochloricum*, Ph. Lond.); or sometimes *chlorhydric acid*.

PREPARATION.—This is obtained by submitting a mixture of common salt (chloride of sodium) and oil of vitriol to distillation in a proper apparatus, and condensing the hydrochloric acid gas which passes over in water contained in the receiver. Manufacturers of hydrochloric acid generally employ an iron or stoneware pot set in brickwork over a fire-place, with a stoneware head luted to it, and connected with a row of double-necked bottles, made of the same material, and furnished with stop-cocks of earthenware. The last bottle is supplied with a safety tube, dipping into a vessel of water (fig. 68).

FIG. 68.



Apparatus for making Hydrochloric Acid.

The liquid obtained by this process is yellow, and constitutes *commercial muriatic acid* (*acidum muriaticum venale; hydrochloric acid of commerce*, Ph. Ed.)

Since the manufacture of carbonate of soda from the sulphate of soda, and the consequent necessity of obtaining the latter salt in large quantities, another mode of making hydrochloric acid has been sometimes adopted. It consists in using a semi-cylindrical vessel for the retort: the upper or flat surface of which is made of stone, while the curved portion exposed to the fire is formed of iron. The chloride of sodium is introduced at one end, which is then closed by an iron plate, perforated to allow the introduction of the leg of a curved leaden funnel, through which strong sulphuric acid is poured. The funnel is then removed, and the aperture closed. Heat being applied, the hydrochloric acid gas is developed, and is conveyed by a pipe into a double-necked stoneware bottle, half filled with water, and connected with a row of similar bottles likewise containing water.

The British Pharmacopœias give directions for making hydrochloric acid. The *Edinburgh College* directs the common salt to be previously purified—

"by dissolving it in boiling water; concentrating the solution; skimming off the crystals as they form on the surface; draining from them the adhering solution as much as possible; and, subsequently, washing them with cold water slightly."

The *London College* uses Chloride of Sodium dried, lbij.; Sulphuric Acid, ℥xx.; Distilled Water, f℥xxiv.

The *Edinburgh College* employs equal weights of Common Salt, purified by recrystallization, subsequently washing them with cold water, and then drying them; Pure Sulphuric Acid; and Water.

The *Dublin College* orders of Dried Muriate of Soda, 100 parts; Sulphuric Acid of commerce, 87 parts; and Water, 124 parts.

The Chloride of Sodium is to be introduced into a glass retort, and the Sulphuric Acid mixed with part [f℥xij. *L.*; one-third, *E.*; one-half, *D.*] of the Water [and allowed to cool, *E.*] is then poured over the Salt; the remainder of the water being placed in the receiver. Distillation is then to be effected [by a sand-bath, *L.*; or by a naked gas-flame, *E.*] so that the gas may pass over into the water contained in the receiver [which is to be kept cool by snow, or a stream of cold water, *E.*] The Acid thus procured is called, by the Edinburgh College, *Acidum muriaticum purum.*

The *theory* of the above process is precisely that already explained in the manufacture of hydrochloric acid gas (see *ante*, p. 375). The salt is dried, to expel any water which may be mechanically lodged between the plates of the crystal, and to obtain uniform weights. Common salt frequently or usually contains traces of nitrate of soda; and in consequence yields, by distillation with sulphuric acid, hydrochloric acid contaminated with chlorine. To get rid of the nitrate, the chloride should either be exposed to a full red heat before it is placed in the still, or purified by recrystallization and washing as recommended by the Edinburgh College.

Unless care be taken to use pure sulphuric acid, the resulting watery hydrochloric acid will be contaminated with various impurities derived from the oil of vitriol (see pp. 355 and 356).

Dr. Gregory[1] gives the following directions for preparing pure liquid hydrochloric acid:—

"6 parts by weight of pure salt are introduced into a flask or mattrass, and covered with 10 parts by weight of oil of vitriol, and 4 parts of water, the latter having been previously mixed, and the mixture allowed to cool: or we may take 8·5 parts of sulphuric acid sp. gr. 1·65. No action takes place in the cold, so that we may adapt securely a bent tube to convey the gas to the flask (fig. 69). This tube is twice bent at right angles, and has a bulb blown on the longer descending limb. In a bottle surrounded with ice-cold water is placed a quantity of distilled water equal in weight to the salt, and the bent tube is made to dip about an eighth of an inch into this water. A gentle heat is now applied to the flask, which rests in a sand-pot, and continued as long as any hydrochloric acid comes over. In about two hours the process is finished, and we find the distilled water increased in volume nearly two-thirds, and converted into hydrochloric acid, quite pure and colourless, of sp. gr. 1·14 to 1·15. If we wish it as strong as

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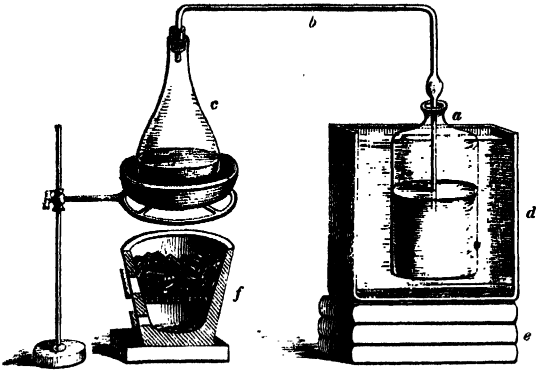
[1] *Outlines of Chemistry*, Part i. p. 72, 1845.

FIG. 69.



Hydrochloric Acid Apparatus.

possible, or of sp. gr. 1·21, we have only to employ, in a second operation, a part of the acid above described in the place of the distilled water, during the first half of the operation, when it will speedily become saturated. No safety tube is required; it is only necessary to lower the bottle a little, occasionally, so that the tube shall never dip far into the liquid; and even should absorption take place too rapidly, and the water rise in the tube, the bulb will receive it, the end of the tube will be exposed, and air entering will prevent the regurgitation of water into the flask. This simple tube, therefore, forms a self-acting valve, and renders a safety tube unnecessary. The absorbing liquid must be kept as cold as possible, by frequently changing the surrounding water, which becomes warm owing to the heat developed in the absorption. If ice can be had, a little added to the cooling-vessel from time to time keeps the temperature sufficiently low.

"In the above operation, the proportions of acid and salt are according to the formula $NaCl + 2 (HO,SO^3) = (NaO,HO,2SO^3) + HCl$. Here, 2 eq. of acid are employed for one of salt, for two reasons: 1st, a much lower heat is required; and 2dly, the resulting salt, bisulphate of soda, is quite easily got out without risking the flask, which is not the case when 1 eq. of acid is used, and neutral sulphate is left. The acid is diluted to sp. gr. 1·65, or even 1·60, for the same reasons. The addition of the water facilitates the operation, and renders the resulting mass more soluble and manageable. It is to be observed that, notwithstanding this addition of water, two-thirds of the hydrochloric acid gas comes off quite dry, and it is only towards the end of the operation that, the heat being increased, water and acid come off together. This is easily known by the tube becoming hot from the condensation of the steam. From first to last not a trace of sulphuric acid passes over, even into the tube; and thus by using tolerably pure materials, we obtain colourless and pure hydrochloric acid, as easily and cheaply as if we were making the very impure acid of commerce. By the above process, the purest and strongest hydrochloric acid might be sold for not more than 3d. per lb., probably for less."

The quantity of strong sulphuric acid (HO,SO^3) required to saturate 2 lbs. of common salt is $19\frac{6}{10}$ oz.; so that the London College employs a slight excess only; whereas the Edinburgh College directs a much greater excess.

In commerce, a liquid called pure muriatic acid is obtained in the manufacture of *spirit of tin*. Tin is dissolved in commercial muriatic acid, and the solution submitted to heat in green glass retorts: muriatic acid distils over, and the residue in the retort constitutes spirit of tin.

PROPERTIES.—Pure watery or liquid hydrochloric acid (*acidum hydrochloricum purum*) is colourless, evolves acid fumes in the air, and possesses the usual characteristics of a strong acid. It has the odour and taste of the gaseous acid. Its specific gravity varies with its degree of concentration. The London College fixes it at 1·16; the Edinburgh College at 1·170. It is decomposed by some metals (*e. g.* zinc and iron), hydrogen being evolved, and a metallic chloride formed. It reacts on those oxyacids which contain five equivalents of oxygen each (*e. g.* nitric, chloric, iodic, and bromic acids): the oxygen of these acids unites with the hydrogen of the hydrochloric acid to form water. When it acts on a metallic oxide, water and a metallic chloride are produced.

Characteristics.—Hydrochloric acid yields, with nitrate of silver, a white, clotty, fusible precipitate (*chloride of silver*), which is insoluble in nitric acid, soluble in ammonia, and blackens by exposure to light (see *ante*, p. 369). When pure, it is without action on gold leaf, and does not decolorize sulphate of indigo. A rod dipped in a solution of caustic ammonia produces white fumes (*sal ammoniac*) when brought near strong liquid hydrochloric acid.

COMPOSITION.—Liquid hydrochloric acid is composed of *water*, holding in solution *hydrochloric acid gas*. When its sp. gr. is 1·162, its composition, according to Dr. Thomson,[1] is as follows:—

	Atoms.	*Eq. Wt.*	*Thomson.*
Hydrochloric acid gas	1	37	33·95
Water	8	72	66·05
Liquid hydrochloric acid, sp. gr. 1·162	1	109	100·00

In the London Pharmacopœia, it is stated that 132 grains of crystallized carbonate of soda saturate 100 grains of acid, sp. gr. 1·16. This would indicate a per-centage strength of 33·916.

DR. THOMSON'S TABLE, EXHIBITING THE SPECIFIC GRAVITY OF HYDROCHLORIC ACID OF DETERMINATE STRENGTHS.

Atoms of Water to one of Acid.	*Real Acid in 100 of the Liquid.*	*Specific Gravity.*	*Atoms of Water to one of Acid.*	*Real Acid in 100 of the Liquid.*	*Specific Gravity.*
6	40·659	1·203	14	22·700	1·1060
7	37·000	1·179	15	21·512	1·1008
8	33·945	1·162	16	20·442	1·0960
9	31·346	1·149	17	19·474	1·0902
10	29·134	1·139	18	18·590	1·0860
11	27·206	1·1285	19	17·790	1·0820
12	25·517	1·1197	20	17·051	1·0780
13	24·026	1·1127			

IMPURITIES.—Commercial hydrochloric acid is always more or less impure. The substances with which it has been found to be contaminated are *sulphuric acid*, *sulphurous acid*, *nitrous acid*, *chlorine*, *chloride of arsenic*, and *sesquichloride of iron*.

1. *Sulphuric acid* (free or combined) may be detected by adding to the suspected acid a solution of chloride of barium (or nitrate of baryta): if sulphuric acid be present, a heavy white precipitate of sulphate of baryta is procured, which is insoluble in nitric acid. In applying this test, the suspected acid should be previously diluted with five or six times its volume of water; otherwise a fallacy may arise from the crystallization of the chloride of barium.

2. *Sulphurous acid* (formed by the action of sulphuric acid on the iron pot) is detected by protochloride of tin, which, after some time, yields a yellow, then a brown precipitate of sulphuret of tin.

3. *Nitrous acid* is detected by pure oil of vitriol and sulphate of iron (see *ante*, p. 356).

4. *Chlorine* gives a yellow colour to hydrochloric acid. It may be detected

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[1] *An Attempt to establish the First Principles of Chemistry*, vol. i. p. 87, Lond. 1825.

by its odour, by its enabling the liquid to dissolve leaf-gold, and by its decolourizing a solution of sulphate of indigo.—A solution of protochloride of tin is the readiest test for detecting any gold which may be dissolved, with which it forms a purplish or blackish precipitate.

5. The presence of *iron* (derived from the iron pot) is shown by saturating the acid with carbonate of soda, and then applying tincture of nutgalls, which produces a black tint. Another mode is to supersaturate the liquid with ammonia or its sesquicarbonate, by which the red or sesquioxide of iron will be precipitated.

6. *Arsenic* has been occasionally found in hydrochloric acid. It is derived from the employment of arsenical oil of vitriol (see *ante*, p. 356) in its manufacture; and is doubtless in the state of chloride of arsenic. It may be detected by Marsh's test, or by diluting the acid and transmitting sulphuretted hydrogen through it, by which orpiment (AsS^3) is precipitated.

7. *Fixed impurities* are found in the residue after the distillation of the acid.

8. The *strength* of the acid is determined by its sp. gr. and its saturating power.

The following are the characters of pure hydrochloric acid as given by the London College:—

> Colourless; entirely vapourizable by heat. When mixed with distilled water, neither chloride of barium nor ammonia, nor the sesquicarbonate of ammonia, throws down any thing. Strips of gold, even when heated in it, are not acted upon by it. It does not destroy the colour of the solution of sulphate of indigo. Its specific gravity is 1·16. 132 grains of crystals of carbonate of soda are saturated by 100 grains of this acid.

To the above should be added, that sulphuretted hydrogen being transmitted through it produces no yellow or brownish colour. The Edinburgh College fixes the density at 1·180.

PHYSIOLOGICAL EFFECTS. *a. On Dead Animal Matter.*—Very dilute hydrochloric acid, mixed with dried mucous membrane, has the property of dissolving various animal substances (as coagulated albumen, fibrin of the blood, boiled meat, &c.), and of effecting a kind of artificial digestion of them, somewhat analogous to the natural digestive process.[1]

β. On Animals.—The effects of liquid hydrochloric acid on living animals (horses and dogs) have been investigated by Sproegel, Courton, Viborg,[2] and by Orfila.[3] Thrown into the veins, it coagulates the blood and causes speedy death. Small quantities, however, may be injected without giving rise to fatal results. Thus Viborg found that a horse recovered in three hours from the effects of a drachm of the acid, diluted with two ounces of water, thrown into a vein. Administered by the stomach to dogs, the undiluted acid acts as a powerful caustic poison. Exhalations of the acid vapours take place through the mouth and nostrils, and death is generally preceded by violent convulsions.

γ. On Man.—Properly diluted, and administered *in small but repeated doses*, hydrochloric acid produces the usual effects of a mineral acid before described (pp. 94 and 170). It usually causes a sensation of warmth in the stomach, relaxes the bowels, and increases the frequency of the pulse. *Larger*

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[1] Müller, *Elements of Physiology*, p. 544.

[2] Wibmer, *Die Wirkung der Arzneimittel und Gifte.*

[3] *Toxicologie Générale.*

doses are said to have excited giddiness and a slight degree of intoxication or stupor. In a *concentrated form* it operates as a powerfully caustic poison. The only recorded cases of poisoning by it (in the human subject) with which I am acquainted, are one mentioned by Orfila[1] and another related by my friend and former pupil, Mr. John Quekett.[2] In the latter case the stomach and duodenum were found, after death, to be charred, and the gall-bladder was observed to have a green tint at the part where it was in contact with the stomach [from the action of the acid on the bile?]. It is remarkable that the contents of the stomach manifested no acidity to litmus; nor could any chloride be recognised by nitrate of silver, either in the decoction of the stomach and duodenum or in the contents of the stomach. The particular nature of the chemical changes effected by it in the organic tissues with which it comes in contact, is not so well understood as in the case of sulphuric or nitric acid. Its chemical action is less energetic than either nitric or sulphuric acid.

USES. α. *Internal* or *Remote*.—Hydrochloric acid has been employed in those diseases formerly supposed to be connected with a putrescent condition of the fluids; as the so-called putrid and petechial fevers, malignant scarlatina, and ulcerated sore-throat. It is usually administered in these cases in conjunction with the vegetable tonics; as cinchona or quassia. It is frequently employed to counteract phosphatic deposits in the urine (see *ante*, pp. 173 and 174). After a copious evacuation, it is, according to Dr. Paris, the most efficacious remedy for preventing the generation of worms; for which purpose the infusion of quassia, stronger than that of the Pharmacopœia, is the best vehicle. It has been employed with benefit in some forms of dyspepsia. Two facts give a remarkable interest to the employment of this acid in dyspeptic complaints—namely, that it is a constituent of the healthy gastric juice;[3] and secondly, when mixed with mucus, it has a solvent or digestive power in the case of various articles of food, as before mentioned. Lastly, hydrochloric acid has been used in scrofulous and venereal affections,[4] in hepatic disorders, &c.

β. *External*.—In the concentrated form it is employed as a caustic to destroy warts, and as an application in sloughing phagedæna, though for the latter purpose it is inferior to nitric acid. Van Swieten[5] employed it in cancrum oris; and more recently Bretonneau[6] has spoken in the highest terms of its efficacy in angina membranacea, commonly termed diphtheritis. It is applied to the throat by a sponge. Properly diluted, it forms a serviceable gargle in ulceration of the mouth and throat. The objection to its use as a gargle is its powerful action on the teeth: to obviate this as much as possible, the mouth is to be carefully rinsed each time after using the gargle. It is sometimes applied to ulcers of the throat by means of a sponge. Water acidulated with this acid has been applied to frost-bitten parts, to chilblains, &c. An injection composed of from eight to twelve drops of the acid to three or four ounces of water, has been employed as an injection in gonorrhœa.

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[1] *Toxicologie Générale.*

[2] *London Medical Gazette*, vol. xxv. p. 285, Nov. 15, 1839.

[3] It has recently been stated, that the free acids of the gastric juice are the phosphoric and lactic; and that the hydrochloric is derived from the chlorides of sodium and potassium.

[4] *London Medical Review*, vol. ii. p. 278, Lond. 1800.

[5] *Commentaries*, Eng. Transl. vol. iv. p. 31, Edinb. 1776.

[6] *Recherches sur l'Inflammation spéciale du tissu muqueux, et en particulier sur la diphthérite, angine maligne, ou croup épidémique*, Paris, 1826.

Administration.—It is given, properly diluted, in doses of from five to fifteen or twenty minims.

Antidotes.—In a case of poisoning by hydrochloric acid, the antidotes (see *ante*, p. 160) are chalk, whiting, magnesia or its carbonate, and soap; and in the absence of these, oil, the bicarbonated alkalies, milk, white of egg, or demulcents of any kind. Of course the gastro-enteritis is to be combated in the usual way.

ACIDUM HYDROCHLORICUM DILUTUM, L.; *Acidum Muriaticum dilutum*, E.; *Diluted Muriatic Acid*.—(Hydrochloric acid, f℥iv.; Distilled water, f℥xij. "The density of this preparation is 1·050," *E.*) The dose is from ʒss. to ʒj. The most agreeable mode of exhibiting it is in the infusion of roses, substituting the hydrochloric for sulphuric acid.

17. Sulphuris Dichloridum.—Dichloride of Sulphur.

Formula S^2Cl. *Equivalent Weight* 67·5. *Equivalent Volume of the Vapour* 1 or □

Protochloride of sulphur; hypochloride of sulphur; subchloride of sulphur; sulphur chloratum; hypochloretum sulphurosum; bisulphuret of chlorine; chlorum hypersulphuratum.—Discovered by Dr. T. Thomson in 1803. Obtained by transmitting dry chlorine gas over washed and dried flowers of sulphur until these are for the most part dissolved. The decanted fluid is to be distilled by a gentle heat from the excess of dissolved sulphur.

It is a brownish yellow oily liquid, whose specific gravity is 1·687. It fumes in the air. Its odour is strong, and somewhat like that of sea plants. Its taste is acrid, hot, and bitter. When the eyes are exposed to its vapour, it excites a copious flow of tears, and a painful sensation, like that caused by peat-smoke. When dropped into water, it is gradually converted into hydrochloric acid, sulphur, and hyposulphurous acid; the latter resolving itself into sulphurous acid and sulphur. $2S^2Cl + 2HO = 2HCl + SO^2 + 3S$. It consists of 32 parts of sulphur and 35·5 of chlorine.

Dichloride of sulphur has been employed in medicine both as an external and as an internal remedy. In obstinate lepra and psoriasis, an ointment composed of one drachm of the dichloride to an ounce of lard has been used with great success. Biett also employed it in the form of ointment in skin diseases (Merat and De Lens). Internally, Derksenye[1] employed it in obstinate gouty pains with stomach complaints, and also in a dangerous nervous fever. He gave it in doses of ten drops, dissolved in ether, and taken in wine. It deserves, however, to be noticed, that although ether at first dissolves, it gradually decomposes the dichloride.

ORDER VIII. IODINE AND ITS COMBINATIONS WITH OXYGEN, HYDROGEN, SULPHUR, AND CHLORINE.

18. IODINIUM.—IODINE.

Symbol I. *Equivalent Weight* 126. *Equivalent Volume of Iodine Vapour* 1 or □

History.—Iodine was discovered in 1811 by M. Courtois, a saltpetre manufacturer at Paris. It was first described by Clement in 1813, but was afterwards more fully investigated by Davy and Gay-Lussac. It was named *iodine* (*iodinium*, Ph. L. and D.; *iodineum*, Ph. Ed.; *iodum*; *iodina*), from ἰώδης, *violet-coloured;* on account of the colour of its vapour.

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[1] Duflos, *Die Lehre von d. Chem. Arzneimitteln.*, Breslau, 1842.

NATURAL HISTORY.—It exists in both kingdoms of nature.[1]

α. IN THE INORGANISED KINGDOM.—Vauquelin met with iodide of silver in a mineral brought from Mexico; and Mentzel found iodine in an ore of zinc which contained cadmium. It has also been met with in an ore of lead.[2] Del Rio found iodide of mercury in Mexico. Iodine is said to have been found in coals.[3] An alkaline iodide has been detected in the Chili nitrate of soda. In sea water, iodine has likewise been discovered, where it probably exists as an iodide of sodium or of magnesium. Many mineral waters contain it. It was detected by Mr. Copeland[4] in the carbonated chalybeate of Bonnington. About one grain of iodine was found by Dr. Daubeny[5] in ten gallons of the water of Robin's Well at Leamington, in Warwickshire. In the old well at Cheltenham, the quantity was not more than one grain in sixty gallons. It is a frequent constituent of brine springs (see *ante*, p. 302). In a brine spring at Nantwich, in Cheshire, there was about a grain of iodine in twelve gallons. In the sulphurous water of Castel Nuovo d'Asti, iodine was discovered by Cantu. In some of the mineral waters of Germany, Bavaria, and South America, it has also been detected.[6] Fuchs found it in the rock salt of the Tyrol.[7]

β. IN THE ORGANISED KINGDOM.—Of animals containing iodine I may mention the genera *Spongia*, *Gorgonia*, *Doris*, *Venus*, &c.: likewise *Sepia*, the envelopes of the eggs of which contain it. An insect has been found near Ascoli, in Italy, which Savi has described under the name of *Julus fœtidissimus*, containing iodine. The animal emits, when disturbed, a yellow fluid strongly smelling of iodine, and which immediately strikes the characteristic violet colour with starch.[8] Iodine has been detected in the oil of the cod's liver.[9] A very considerable number of vegetables, particularly those belonging to the family Algæ, yield it. The following are some instances:—*Fucus vesiculosus*, *F. serratus*, and *F. nodosus; Laminaria saccharina*, and *L. digitata; Halidrys siliquosa; Chorda Filum; Gelidium cartilagineum; Halyseris polypodioides; Phyllophora rubens; Rhodomenia palmata; Ulva Linza; Porphyra umbilicalis; Padina Pavonia; Gigartina Helminthocorton;* and some of the marine *Confervæ*.

"The following table, drawn up by Mr. Whitelaw, a manufacturer in Glasgow, from his own experiments, shows the proportion of iodine contained in some of the most common Algæ on our sea coasts:—

	Ratios of Iodine.		*Ratios of Iodine.*
Laminaria digitata	100	Fucus serratus	20
Laminaria bulbosa	65	Fucus bulbosus	15
Laminaria saccharina	35		

"The quantities of chloride of potassium in those Algæ follow nearly the same ratio."[10] Professor Graham states that, according to Mr. Whitelaw, the long elastic stems of the *Rhodomenia palmata* afford most of the iodine contained in kelp.

Professor Graham[11] has suggested the manufacture of iodine from Guernsey kelp, which, being the produce of deep sea fuci, contains more iodine than ordinary kelp.

It has been found in several species of phænogamous plants, as *Zostera marina;* and, more recently, in two growing in Mexico—namely, a species of *Agave*, and one of *Salsola*.[12]

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[1] Since the publication of the first edition of this work, I have met with S. E. Sarphati's *Commentatio de Iodio*, Lugduni, 1835, in which is found the most extensive list of natural bodies containing iodine of any work with which I am acquainted.

[2] *Journ. de Pharmacie*, tom. xxiii. for 1837, p. 29.

[3] *Lond. and Edinb. Philosoph. Mag.* for Nov. 1839.

[4] *Edinburgh New Philosophical Journal*, vol. i. p. 159.

[5] *Phil. Trans.* 1830, Part ii. p. 223.

[6] Gairdner, *Essay on the Natural History, Origin, Composition, and Medicinal Effects of Mineral and Thermal Springs*, p. 27, Edinb. 1832.

[7] Gmelin, *Handbuch der Chemie*, Bd. i. S. 350.

[8] Dulk, *Die Preussische Pharmakopöe*, Bd. i. S. 583, Leipzig, 1829; and *British and Foreign Medical Review* for January 1838, p. 163.

[9] *Journ. de Pharmacie*, tom. xxiii. p. 501.

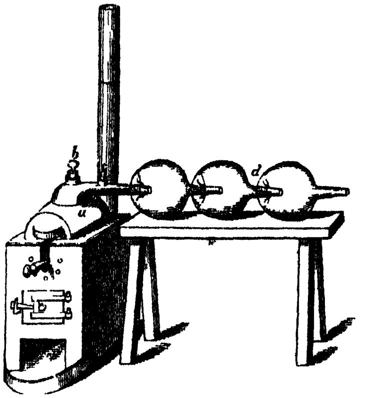
[10] Thomson, *Organic Chemistry*, p. 946.

[11] *Mem. and Proceedings of the Chemical Society*, vol. iii. p. 252.

[12] *Journal de Pharmacie*, t. xxiii. p. 31.

PREPARATION.—British iodine is exclusively manufactured at Glasgow, from the kelp of the west coast of Ireland and the western islands of Scotland. The kelp is broken into pieces and lixiviated in water, to which it yields about half its weight of salts. The solution is concentrated by evaporation, and thereby deposits soda salts (common salt, carbonate and sulphate of soda), and on cooling also lets fall crystals of chloride of potassium. The mother liquor (called *iodine ley*) is dense, dark-coloured, and contains the iodine, in the form, it is believed, of iodide of sodium. Sulphuric acid is added, to render the liquor sour, by which carbonic acid, sulphuretted hydrogen, and sulphurous acid gases, are evolved, and sulphur is deposited. The workmen set fire to the sulphuretted hydrogen as it escapes, to obviate its bad effects. The acid ley is then introduced into a leaden still (fig. 70, *a*), and heated to 140° F., when binoxide of manganese is added. A leaden head, having two stoppers (*b* and *c*), is then adapted and luted with pipe-clay, and to the neck of the head is fitted a series of spherical glass condensers (*d*), each having two mouths opposite to each other, and inserted the one into the other. Iodine is evolved, and is collected in the condensers. The process is watched by occasionally removing the stopper *c*, and additions of sulphuric acid or manganese are made by *b*, if deemed necessary.[1]

FIG. 70.



Iodine leaden still and glass receiver.

The following is the mutual reaction of sulphuric acid, binoxide of manganese, and iodide of sodium:—Two equivalents of sulphuric acid react on one equivalent of binoxide of manganese, and on one equivalent of iodide of sodium; and yield one equivalent of iodine, one equivalent of sulphate of soda, and one equivalent of the sulphate of the protoxide of manganese. $NaI + MnO^2 + 2SO^3 = NaO, SO^3 + MnO, SO^3 + I$.

MATERIALS.		COMPOSITION.			PRODUCTS.	
1 eq. Iodide of Sodium .	149	*1 eq. Iodine*........	126		1 eq. Iodine	126
		1 eq. Sodium	23	*1 eq. Soda* 31		
1 eq. Binoxide Mangan.	44	*1 eq. Oxygen*	8			
		1 eq. Protox. Mang.	36			
2 eq. Sulphuric Acid...	80	*1 eq. Sulph. Acid* .	40		1 eq. Sulphate Soda	71
		1 eq. Sulph. Acid...	40		1 eq. ProtosulphateMang.	76
	273		273			273

The evolution of iodine in the preceding process may be also accounted for in another way. By the mutual reaction of sulphuric acid, binoxide of manganese and a chloride (as of sodium or potassium), chlorine is set free. This reacting on iodide of sodium, would liberate iodine, and form chloride of sodium. Or, the hydriodic acid set free from a solution of iodide of sodium by sulphuric acid, may be decomposed by the nascent chlorine.

PROPERTIES.—Iodine is a crystallizable solid, its primary form being a rhombic octohedron[2] (see *ante*, p. 141). It is usually met with in micaceous, soft, friable scales, having a greyish-black colour, a metallic lustre, an acrid, hot taste, and a disagreeable odour, somewhat similar to that of chlorine. It fuses at about 225° F., and at 347° is volatilized, though the vapour rises along with that of water at 212°. Iodine vapour is of a beautiful violet colour and has a great specific gravity—namely, 8·716, according to Dumas. Iodine requires 7000 times its weight of water to dissolve it, but alcohol and ether are much better solvents for it.

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[1] For further details, consult Graham's *Elements of Chemistry*, vol. i. p. 384. See also Dr. Thomson, in the *Athenæum* for 1840, p. 772.

[2] Buchner's *Repertorium für die Pharmacie*, 2ter Reihe, Band. xx. S. 48, Nürnberg, 1841.

Characteristics.—In the free state iodine is distinguished from most other bodies by the violet colour of its vapour, and by its forming a blue compound (*iodide of starch*) with starch. So delicate is this test, that, according to Stromeyer, water which does not contain more than one-four-hundred-and-fifty thousandth of its weight of iodine, acquires a perceptibly blue tinge on the addition of starch. This blue colour is destroyed by heat; and, therefore, in testing for iodine, the liquids employed should be cold: an excess of alkali also destroys it by forming two salts, an iodate and an iodide, but by supersaturating with acid the colour is restored. The action of iodine on starch is also impeded by some organic constituents of plants.

Indigo-blue, when heated on platinum-foil, evolves a purplish smoke somewhat similar in colour to the vapour of iodine.

Iodine as well as the mineral acids (sulphuric, nitric, and hydrochloric,) produce a blue colour with narceine (see *Opium*).

When iodine is in combination with oxygen, starch will not recognise it. For example, if a little starch be added to a solution of *iodic acid*, no change of colour is observed; but if some deoxidating substance be now employed (such as sulphurous acid) the blue colour is immediately produced. If iodine be combined with a base (as with hydrogen, potassium, or sodium,) forming a soluble *iodide*, chlorine or sulphuric or nitric acid must be employed to remove the base; and the iodine being then set free, will react on the starch. This is the mode of proceeding to detect iodine in the urine of a patient; for the mere addition of starch will not suffice. Excess of chlorine will unite with the disengaged iodine, and cause the blue colour to disappear.

The metallic *iodides* are known as follows:—Heated with concentrated sulphuric acid in a glass tube, they evolve gaseous iodine, known by its violet colour. The insoluble iodides are frequently characterised by their colour: heated with carbonate of potash, they are decomposed, and yield iodide of potassium. The soluble iodides are recognised by the action of nitric acid and starch, above mentioned. They yield with nitrate of silver a yellowish-white precipitate (*iodide of silver*), which, like chloride of silver, is insoluble in dilute nitric acid, but, unlike this, is scarcely soluble in caustic ammonia. The iodides also yield a yellow precipitate (*iodide of lead*) with a solution of the salts of lead, and a scarlet precipitate (*biniodide of mercury*) with the bichloride of mercury.

IMPURITIES.—The iodine of commerce is always contaminated with variable proportions of *water*. An ounce, if very moist, may contain a drachm, or perhaps even a drachm and a half, of water. This fraud is detected by compressing the iodine between folds of blotting-paper. In this moist state it is "unfit for making pharmaceutic preparations of fixed and uniform strength," and the Edinburgh College gives the following directions for purifying it:—

"It must be dried by being placed in a shallow basin of earthenware in a small confined space of air, with ten or twelve times its weight of fresh-burnt lime, till it scarcely adheres to the inside of a dry bottle."

To obtain it in large crystals, it requires to be resublimed in an alembic on a sand-bath.

Various substances, such as *coal, plumbago, binoxide of manganese, sand,* and *charcoal,* are also said to have been employed for the purpose of adulterating iodine; but in no samples of iodine which I have examined have I ever found any of these substances. Pure iodine is completely soluble in alcohol, and evaporates, when heated, without leaving any residuum. Any matter insoluble in alcohol, or not vaporizable by heat, is an adulteration. The Edinburgh College gives the following criteria of its goodness:—

> "Entirely vapourizable: thirty-nine grains, with nine grains of quicklime and three ounces of water, when heated short of ebullition, slowly form a perfect solution, which is yellowish or brownish, if the iodine be pure, but colourless if there be above two per cent. of water or other impurity."

PHYSIOLOGICAL EFFECTS. α. *On Vegetables.*—Cantu states that seeds placed in pure sand and moistened with a solution of iodine, germinate more readily than seeds sown in the usual way. Vogel, however, asserts that iodine, so far from promoting, actually checks or stops germination.[1]

β. *On Animals generally.*—On horses, dogs, and rabbits, it operates as an irritant and caustic poison, though not of a very energetic kind. Magendie threw a drachm of the tincture of iodine into the veins of a dog without causing any obvious effects.[2] Dr. Cogswell has repeated this experiment: the animal was slightly affected only.[3] The last-mentioned writer found that two drachms of the tincture caused death. But something must be ascribed to the alcohol employed. Orfila[4] applied 72 grains of solid iodine to a wound on the back of a dog: local inflammation, but no other inconvenience, resulted. One or two drachms administered by the stomach caused vomiting, and when this was prevented by tying the œsophagus, ulceration of the alimentary canal and death took place. Mr. Dick[5] gave iodine in very large doses to a horse for three weeks, but the only symptom which could be referred to its influence was an unusual disregard for water. The average daily allowance was two drachms, administered in quantities ascending from a drachm up two ounces. Dr. Cogswell[6] gave 73 grains of iodine to a dog in nine days. Five days after the cessation of the iodine, the dog was killed: the urine contained a highly appreciable quantity of iodine, and a trace, and but a trace, of iodine was found in the blood, brain, and stomach.

γ. *On Man.*—The *local* action of iodine is that of an irritant. The nature of its chemical action on the tissues has been already explained (see *ante,* p. 93). Applied to the skin, it stains the cuticle orange-yellow, causes itching, redness, and desquamation. If the vapour of it, mixed with air, be inhaled, it excites cough and heat in the air-passages. On a secreting surface its alcoholic solution acts as a desiccant. Swallowed in large doses, it irritates the stomach, as will be presently mentioned.

The general effects of iodine and its compounds on the body have been already noticed (see *ante,* p. 182). They may be considered under the two heads—of those arising from the use of small, and those produced by large doses.

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[1] De Candolle, *Physiologie Végétale,* t. 3me, p. 1337.

[2] *Formulaire.*

[3] *Experimental Essay on Iodine,* p. 31, 1837.

[4] *Toxicologie générale.*

[5] Cogswell's *Essay,* p. 24.

[6] *Op. cit.* p. 60.

aa. In small, medicinal doses, we sometimes obtain the palliation, or even the removal of disease, without any perceptible alteration in the functions of the body. Thus, in a case of chronic mammary tumor which fell under my observation, iodine was taken daily for twelve months, without giving rise to any perceptible functional change, except that the patient was unusually thin during this period. Sometimes it increases the appetite—an effect noticed both by Coindet[1] and by Lugol,[2] from which circumstance it has been denominated a *tonic*. But the long-continued use of it, in large doses, has occasionally brought on a slow or chronic kind of gastro-enteritis—an effect which I believe to be rare, and only met with when the remedy has been incautiously administered.

In irritable subjects, and those disposed to dyspepsia, it occasions nausea, sickness, heat of stomach, and loss of appetite, especially after its use has been continued for some days; the bowels are oftentimes slightly relaxed, or at least they are not usually constipated. More than one-third of the patients treated by Lugol experienced a purgative effect; and when the dejections were numerous, colics were pretty frequent.[3] Gendrin[4] and Manson,[5] however, observed a constipating effect from the use of iodine.

The action of iodine on the *organs of secretion* is, for the most part, that of a stimulant; that is, the quantity of fluid secreted is usually increased, though this effect is not constantly observed. Jörg[6] and his friends found, in their experiments on themselves, that small doses of iodine increased the secretion of nasal mucus, of saliva, and of urine, and they inferred that the similar effect was produced on the gastric, pancreatic, and biliary secretions. "Iodine," says Lugol,[7] "is a powerful *diuretic*. All the patients using it have informed me that they pass urine copiously." Coindet, however, expressly says that it does not increase the quantity of urine. In some cases in which I carefully watched its results, I did not find any diuretic effect. Iodine frequently acts as an *emmenagogue*. Coindet, Sablairoles,[8] Brera,[9] Magendie,[10] and many others, agree on this point; but Dr. Manson[11] does not believe that it possesses any emmenagogue powers, further than as a stimulant and tonic to the whole body. In one patient it occasioned so much sickness and disorder of stomach, that the menstrual discharge was suppressed altogether. On several occasions iodine has caused *salivation* and soreness of mouth. In the cases noticed by Lugol the patients were males. In the *Medical Gazette*, vol. xvii. for 1836, two instances are mentioned,—one by Mr. Winslow (p. 401), the other by Dr. Ely (p. 480). Other cases are referred to in Dr. Cogswell's work. This effect, however, I believe to be rare. De Carro (quoted by Bayle[12]) denies that iodine causes salivation, but says it augments *expectoration*. Lastly, *diaphoresis* is sometimes promoted by iodine.

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[1] *Biblioth. Univers.* tom. xiv. Sciences and Arts.

[2] *Essays*, translated by Dr. O'Shaughnessy.

[3] *Op. cit.* p. 20.

[4] *Dict. de Mat. Méd.* t. 3me, p. 628.

[5] *Medical Researches on Iodine.*

[6] *Material zu einer Arzneimittell.* Leipzig, 1824.

[7] *Essays*, p. 19.

[8] *Journ. générale de Méd.* t. 97.

[9] Quoted by Bayle, in his *Bibliothèque de Thérapeutique*, t. i. p. 129.

[10] *Formulaire.*

[11] *Medical Researches on the Effects of Iodine*. Lond. 1825.

[12] *Op. cit.* p. 50.

Two most remarkable effects which have been produced by iodine are—*absorption of the mammæ* and *wasting of the testicles.* Of the first of these (absorption of the mammæ), three cases are reported in *Hufeland's Journal,*[1] one of which may be here mentioned. A healthy girl, twenty years of age, took the tincture of iodine during a period of six months for a bronchocele, of which she became cured; but the breasts were observed to diminish in size, and, notwithstanding she ceased to take the remedy, the wasting continued, so that at the end of two years not a vestige of the mammæ remained. Sometimes the breasts waste, though the bronchocele is undiminished: Reichenau[2] relates the case of a female, aged twenty-six, whose breasts began to sink after she had employed iodine for four months, and within four weeks they almost wholly disappeared; yet her goître remained unaffected. With regard to the other effect (wasting of the testicle) I suspect it to be very rare. I have seen iodine administered in some hundreds of cases, and never met with one in which atrophy either of the breast or testicle occurred. Magendie also never saw these effects, though they are frequent in Switzerland.

A disordered condition of the cerebro-spinal system has in several instances been caused by iodine. Thus, slight headache and giddiness are not unfrequently brought on. Lugol tells us that, by the use of ioduretted baths, headache, drowsiness, intoxication, and even stupor, are produced. Analogous symptoms were observed in some of Dr. Manson's cases; and in one there were convulsive movements.

A specific effect on the skin is sometimes produced by iodine, besides the diaphoresis before alluded to. Thus Dr. C. Vogel[3] gives an account of a lady, twenty-eight years of age, of a sallow complexion, who, from the internal employment of the tincture of iodine, became suddenly brown, besides suffering with other morbid symptoms. After some days the skin had the appearance of having been smoked! Mr. Stedman[4] says that in some scrofulous patients it improves the condition of the hair and scalp. Red hair is said to have assumed a chesnut-brown colour under the long-continued internal use of iodine.[5]

The rapid emaciation said to have been occasionally produced by iodine, as well as the beneficial influence of this substance in scrofulous diseases, and the disappearance of visceral and glandular enlargements under its use, have given rise to an opinion that iodine *stimulates the lymphatic vessels and glands* (see *ante,* pp. 175 and 176). Manson, however, thinks that it exerts no peculiar or specific influence over the absorbent system, which only participates in the general effects produced on the whole body. And Lugol asserts, that instead of producing emaciation, it encourages growth and increase of size.

There can be no doubt that the continued use of iodine must have some effect over the general nutrition of the body, and by modifying the actions previously performed by the various organs and symptoms, it may at one time cause the *embonpoint* described by Lugol, and at another have the reverse effect: in one case it may promote the activity of the absorbents, and occasion the removal of tumors of considerable size, in another check ulceration (a process which Mr. Key, in the 19th vol. of the *Medico-Chirurgical Transactions*, denies to be one of absorption, but considers to be one of degeneration or disorganization) and cause the healing of ulcers.

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[1] Bayle, *op. cit.* p. 162.
[2] Christison, p, 180.
[3] Rust, *Magazin,* Bd. xiv. p. 156.
[4] *London Medical Gazette,* vol. xv. p. 447.
[5] Clauzel, *Revue Médicale,* Nov. 1834, p. 30.

Some have ascribed to iodine an *aphrodisiac* operation. Kolley,[1] a physician at Breslau, who took it for a bronchocele, said it had the reverse effect on him.

In some instances, the continued use of iodine has given rise to a disordered state of system, which has been designated *iodism*. The symptoms (termed by Dr. Coindet, *iodic*) are violent vomiting and purging, with fever; great thirst; palpitation; rapid and extreme emaciation; cramps, and small and frequent pulse, occasionally with dry cough; and terminating in death. This condition, however, must be a very rare occurrence; for it is now hardly ever met with, notwithstanding the frequency and freedom with which iodine is employed. But it has been noticed by Coindet,[2] Gardner,[3] Zink,[4] Jahn,[5] and others. The daily experience of almost every practitioner proves, that the dangers resulting from the use of iodine have been much exaggerated, and we can hardly help suspecting that many symptoms, which have been ascribed to the injurious operation of this remedy, ought to have been referred to other causes; occasionally, perhaps, they depended on gastro-enteritis. In some cases, the remarkable activity of iodine may have arisen from some idiosyncrasy on the part of the patient. Dr. Coindet attributes the iodic symptoms to the *saturation* of the system with iodine—an explanation, to a certain extent, borne out by the results of an experiment made by Dr. Cogswell, and which I have before mentioned: I allude, now, to the detection of iodine in the tissues of an animal five days after he had ceased taking this substance.

ββ. *In very large doses* iodine has acted as an irritant poison. In a fatal instance, recorded by Zink,[6] the symptoms were restlessness, burning heat, palpitations, very frequent pulse, violent priapism, copious diarrhœa, excessive thirst, trembling, emaciation, and occasional syncope. The patient died after six weeks' illness. On another occasion this physician had the opportunity of examining the body after death. In some parts the bowels were highly inflamed; in others they exhibited an approach to sphacelation. The liver was very large, and of a pale rose colour.

Such cases, however, are very rare. In many instances, which might be referred to, enormous quantities of iodine have been taken with very slight effects only, or perhaps with no marks of gastric irritation. Thus, Dr. Kennedy,[7] of Glasgow, exhibited within eighty days 953 grains of iodine in the form of tincture: the daily dose was at first two grains, but ultimately amounted to eighteen grains. The health of the girl appeared to be unaffected by it. It should here be mentioned, that the presence of bread, sago, arrowroot, tapioca, or other amylaceous matters, in the stomach, will much diminish the local action of iodine, by forming an iodide of starch, which, as will hereafter be mentioned, is a very mild preparation.[8]

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[1] *Journ. Complém.* t. xvii. p. 307.

[2] *Op. cit.*

[3] *Essay on the Use of Iodine.*

[4] *Journ. Complém.* t. xviii. p. 126.

[5] Quoted by Christison, p. 181.

[6] *Journ. Complém.* t. xviii.

[7] Dr. Cogswell's *Essay.*

[8] See the experiments of Dr. Buchanan, presently to be noticed.

MODUS OPERANDI.—That iodine becomes absorbed, when employed either externally or internally, we have indisputable evidence by its detection, not only in the blood, but in the secretions (see *ante*, pp. 101 and 102). Cantu[1] has discovered it in the urine, sweat, saliva, milk, and blood. In all cases it is found in the state of iodide. Bennerscheidt[2] examined the serum of the blood of a patient who had employed for some time iodine ointment; but he could not detect any trace of iodine in it. In the crassamentum, however, he obtained evidence of its existence, by the blue tint communicated to starch. It may be readily detected in the urine of patients who have been using iodine, by adding a cold solution of starch and a few drops of nitric acid, when the blue iodide of starch is produced.

USES.—As a remedial agent iodine is principally valuable for its resolvent influence in chronic visceral and glandular enlargements, indurations, thickening of membranes (as of the periosteum), and in tumors. In comparing its therapeutical power with that of mercury, we observe in the first place that it is not adapted for febrile and acute inflammatory complaints, in several of which mercury proves a most valuable agent. Indeed, the existence of inflammatory fever is a contraindication for the employment of iodine. Secondly, iodine is especially adapted for scrofulous, mercury for syphilitic, maladies; and it is well known that in the former class of diseases mercurials are for the most part injurious. Thirdly, the influence of iodine over the secreting organs is much less constant and powerful than that of mercury; so that in retention or suppression of the secretions, mercury is for the most part greatly superior to iodine. Fourthly, iodine evinces a specific influence over the diseases of certain organs (*e. g.* the thyroid body), which mercury does not.—These are some only of the peculiarities which distinguish the therapeutical action of iodine from that of mercury.

a. In *bronchocele.*—Of all the remedies yet proposed for bronchocele, this has been by far the most successful. Indeed, judging only from the numerous cases cured by it, and which have been published, we should almost infer it to be a sovereign remedy. However, of those who have written on the use of iodine in this complaint, some only have published a numerical list of their successful and unsuccessful cases. Bayle[3] has given a summary of those published by Coster, Irmenger, Baup, and Manson, from which it appears, that of 364 cases treated by iodine, 274 were cured. Dr. Copland[4] observes that, of several cases of the disease which have come before him since the introduction of this remedy into practice, "there has not been one which has not either been cured or remarkably relieved by it." I much regret, however, that my own experience does not accord with this statement. I have repeatedly seen iodine, given in conjunction with iodide of potassium, and used both externally and internally, fail in curing bronchocele; and I know others whose experience has been similar. Dr. Bardsley[5] cured only nine, and relieved six, out of thirty cases, with iodide of potassium. To what circumstances, then, ought we to attribute this variable result? Dr. Copland thinks that, where it fails, it has been given in "too large and irritating doses, or in an improper form; and without due attention having been paid to certain morbid and constitutional relations of the disease during the treatment."

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[1] *Journ. de Chimie Méd.*
[2] *Ibid.* t. iv. p. 383.
[3] *Bibliothèque de Thérapeutique*, t. 1er, p. 394.
[4] *Dict. of Pract. Med.*
[5] *Hospital Facts and Observations*, p. 121.

But, in two or three of the instances before mentioned, I believe the failure did not arise from any of the circumstances alluded to by Dr. Copland, and I am disposed to refer it to some peculiar condition of the tumor, or of the constitution. When we consider that the terms *bronchocele*, *goître*, and *Derbyshire neck*, are applied to very different conditions of the thyroid gland, and that the causes which produce them are involved in great obscurity, and may, therefore, be, and indeed probably are, as diversified as the conditions they give rise to, we can easily imagine, that while iodine is serviceable in some, it may be useless, or even injurious, in others. Sometimes the bronchocele consists in hypertrophy of the substance of the thyroid gland,—that is, this organ is enlarged, but has a healthy structure. In others, the tumefaction of the gland takes place suddenly, and may even disappear as suddenly; from which it has been inferred, that the enlargement depends on an accumulation of blood in the vessels, and an effusion of serum into its tissue. Coindet mentions a goître which was developed excessively during the first pregnancy of a young female: twelve hours after her accouchement it had entirely disappeared. The same author also relates the circumstance of a regiment composed of young recruits, who were almost every man attacked with considerable enlargement of the thyroid gland, shortly after their arrival at Geneva, where they all drank water out of the same pump. On their quarters being changed the gland soon regained its natural size in every instance. A third class of bronchoceles consists of an enlargement of the thyroid gland from the development of certain fluid or solid substances in its interior, and which may be contained in cells, or be infiltrated through its substance. These accidental productions may be serous, honey-like, gelatinous, fibrous, cartilaginous, or osseous. Lastly, at times the enlarged gland has acquired a scirrhous condition. Now it is impossible that all these different conditions can be cured with equal facility by iodine; those having solid deposits are, of course, most difficult to get rid of.

Kolley, who was himself cured of a large goitre of ten years' standing, says, that for the iodine to be useful, the bronchocele should not be of too long standing, nor painful to the touch; the swelling confined to the thyroid gland, and not of a scirrhous or carcinomatous nature, nor containing any stony or other analogous concretions; and that the general health be not disordered by any febrile or inflammatory symptoms, or any gastric, hepatic, or intestinal irritation. If the swelling be tender to the touch, and have other marks of inflammation, let the usual local antiphlogistic measures precede the employment of iodine. When this agent is employed we may administer it both externally and internally. The most effectual method of employing iodine externally is that called *endermic*, already described; namely, to apply an ioduretted ointment (usually containing iodide of potassium) to the cutis vera, the epidermis being previously removed by a blister. But the *epidermic* or *iatroleptic* method is more usually followed—that is, the ioduretted ointment is rubbed into the affected part, without the epidermis being previously removed, or the undiluted tincture is repeatedly applied to the part by a camel's-hair pencil, while iodine is at the same time administered internally.

With respect to the internal use of this substance, some think that the success depends on the use of small doses largely diluted; while others consider that as large a quantity of the remedy should be administered as the stomach and general system can bear.

β. Scrofula is another disease for which iodine has been extensively used. Dr. Coindet was, I believe, the first to direct public attention to this remedy in the disease in question. Subsequently, Baup, Gimelle, Kolley, Sablairoles, Benaben, Callaway, and others, published cases illustrative of its beneficial effects.[1] Dr. Manson[2] deserves the credit of having first tried it on an extensive scale. He treated upwards of eighty cases of scrofula and scrofulous ophthalmia by the internal exhibition of iodine, sometimes combined with its external employment; and in a large proportion of cases, where the use of the medicine was persevered in, the disease was either cured or ameliorated, the general health being also improved. Three memoirs on the effects of iodine in scrofula have been subsequently published by Lugol, physician to the Hôpital St.-Louis, serving to confirm the opinions already entertained of its efficacy. From the first memoir it appears, that in seventeen months—namely, from August 1827, to December 1828—109 scrofulous patients were treated by iodine only; and that of these 36 were completely cured, and 30 relieved; in 4 cases the treatment was ineffectual, and 39 cases were under treatment at the time of the report made by Serres, Magendie, and Dumeril, to the Académie Royale des Sciences. In his illustrative cases we find glandular swellings, scrofulous ophthalmia, abscesses, ulcers, and diseases of the bones, were beneficially treated by it. Lugol employs iodine internally and externally: for internal administration, he prefers iodine dissolved in water by means of iodide of potassium, given either in the form of *drops*, or largely diluted, under the form of what he calls *ioduretted mineral water*, hereafter to be described. His external treatment is of two kinds; one for the purpose of obtaining local effects only, the other for procuring constitutional or general effects. His local external treatment consists in employing ointments or solutions of iodine: the *ointments* are made either with iodine and iodide of potassium, or with the protiodide of mercury; the *solutions* are of iodine and iodide of potassium in water; and according to their strength are denominated caustic, rubefacient, or stimulant: the rubefacient solution is employed in making cataplasms and local baths. His external general treatment consists in the employment of *ioduretted baths*. In the treatment of cutaneous scrofula I have seen the most beneficial results from the application of the tincture of iodine by means of a camel's-hair pencil. It dries up the discharge and promotes cicatrization.

The successful results obtained by Lugol in the treatment of this disease cannot, I think, in many instances, be referred to iodine solely. Many of the patients were kept several months (some as much as a year) under treatment in the hospital, where every attention was paid to the improvement of their general health by warm clothing, good diet, the use of vapour- and sulphur-baths, &c.; means which of themselves are sufficient to ameliorate, if not cure, many of the scrofulous conditions before alluded to. Whether it be to the absence of these supplementary means of diet and regimen, or to some other cause, I know not, but most practitioners will, I think, admit, that they cannot obtain, by the use of iodine, the same successful results which Lugol is said to have met with, though in a large number of cases this agent has been found a most useful remedy.

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[1] See Bayle's *Bibliothèque de Thérapeutique*, tom. i.

[2] *Op. cit.*

γ. Iodine has been eminently successful when employed as a resolvent *in chronic diseases of various organs, especially those accompanied with induration and enlargement.* By some inexplicable influence, it sometimes not only puts a stop to the further progress of disease, but apparently restores the part to its normal state. It is usually given with the view of exciting the action of the absorbents, but its influence is not limited to this set of vessels: it exercises a controlling and modifying influence over the blood-vessels of the affected part, and is in the true sense of the word an *alterative* (see *ante*, pp. 175-176).

In chronic inflammation, induration, and enlargement of the *liver*, after antiphlogistic measures have been adopted, the two most important and probable means of relief are iodine and mercury, which may be used either separately or conjointly. If the disease admit of a cure, these are the agents most likely to effect it. Iodine, indeed, has been supposed to possess some specific power of influencing the liver, not only from its efficacy in alleviating or curing certain diseases of this organ, but also from the effects of an overdose. In one case, pain and induration of the liver were brought on; and in another, which terminated fatally, this organ was found to be enlarged, and of a pale rose colour.[1]

Several cases of enlarged *spleens* relieved, or cured, by iodine have been published.

In chronic diseases of the *uterus*, accompanied with induration and enlargement, iodine has been most successfully employed. In 1828, a remarkable instance was published by Dr. Thetford.[2] The uterus was of osseous hardness, and of so considerable a size as nearly to fill the whole of the pelvis: yet in six weeks the disease had given way to the use of iodine, and the catamenia were restored. In the *Guy's Hospital Reports*, No. I. 1836, is an account, by Dr. Ashwell, of seven cases of "hard tumors" of the uterus successfully treated by the use of iodine, in conjunction with occasional depletion, and regulated and mild diet. Besides the internal use of iodine, this substance was employed in the form of ointment (composed of iodine, gr. xv., iodide potassium ℈ij., spermaceti oint. ℥iss.), of which a portion (about the size of a nutmeg) was introduced into the vagina, and rubbed into the affected cervix for ten or twelve minutes every night. It may be applied by the finger, or by a camel's-hair pencil, or sponge mounted on a slender piece of cane. The average time in which resolution of the induration is accomplished varies, according to Dr. Ashwell, from eight to sixteen weeks. "In hard tumors of the walls or cavity of the uterus, resolution, or disappearance, is scarcely to be expected;" but "hard tumors of the cervix, and indurated puckerings of the edges of the os (conditions which most frequently terminate in ulceration) may be melted down and cured by the iodine."[3]

In *ovarian* tumors, iodine has been found serviceable.[4] In the *chronic mammary tumor*, described by Sir A. Cooper, I have seen it give great relief—alleviating pain, and keeping the disease in check. In *indurated enlargements of the parotid, prostate and lymphatic glands*, several successful cases of its use have been published.

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[1] Christison, *Treatise on Poisons*, pp. 180-1.

[2] *Transactions of the King and Queen's College of Physicians, Ireland*, vol. v.

[3] *Op. cit.* pp. 152-3.

[4] For some remarks, by Sir B. Brodie, on the use of iodine in morbid growths, see Dr. Seymour's *Illustrations of some of the Principal Diseases of the Ovaria*, Lond. 1830. Also, *London Medical Gazette*, vol. v. p. 750.

δ. As an *emmenagogue*, iodine has been recommended by Coindet, Brera, Sablairoles, Magendie, and others. The last-mentioned writer tells us, that on one occasion he gave it to a young lady, whose propriety of conduct he had no reason to doubt, and that she miscarried after using it for three weeks. I have known it given for a bronchocele during pregnancy without having the least obvious influence over the uterus.

ε. In *gonorrhœa* and *leucorrhœa* it has been employed with success after the inflammatory symptoms have subsided.

ζ. *Inhalation* of *iodine vapour* has been used in phthisis and chronic bronchitis. In the first of these diseases it has been recommended by Berton, Sir James Murray, and Sir Charles Scudamore. I have repeatedly tried it in this as well as in other chronic pulmonary complaints, but never with the least benefit. The apparatus for inhaling it is the same as that used for the inhalation of chlorine (see *ante*, p. 372). The liquid employed is a solution of ioduretted iodide of potassium, to which Sir C. Scudamore adds the tincture of conium.[1]

In the Pharmacopœia of the Parochial Infirmary of St. Marylebone is the following formula for an iodine inhaling liquor:—

Liquor Iodinii ad Inhalationem.—Iodinii, gr. j.; Potassii Iodidi, gr. ss.; Aquæ destillatæ, ℥vij.; Spirit. Vini Rect. ℈jss.; Tinct. Conii saturatæ, ʒj. Drachma una vel drachmæ duæ ex aquâ tepidâ ope tubuli inhaland.

η. *Chronic diseases of the nervous system*, such as paralysis and chorea, have been successfully treated by iodine, by Dr. Manson.

θ. In some forms of *the venereal disease*, iodine has been found a most serviceable remedy. Thus Richond (quoted by Bayle[2]) employed it, after the usual antiphlogistic measures, to remove buboes. De Salle cured chronic venereal affections of the testicles with it. Mr. Mayo[3] has pointed out its efficacy in certain disorders which are the consequences of syphilis, such as emaciation of the frame, with ulcers of the skin; ulcerated throat; and inflammation of the bones, or periosteum,—occurring in patients to whom mercury has been given.

ι. *In checking or controlling the ulcerative process*, iodine is, according to Mr. Key,[4] one of the most powerful remedies we possess. "The most active phagedenic ulcers, that threaten the destruction of parts, are often found to yield in a surprising manner to the influence of this medicine, and to put on a healthy granulating appearance."

κ. Besides the diseases already mentioned, there are many others in which iodine has been used with considerable advantage: for example—*chronic skin diseases*, as lepra, psoriasis, &c.[5] (I have seen it aggravate psoriasis);—*dropsies*;[6] *in old non-united fractures*, to promote the deposition of ossific matter;[7] and *in chronic rheumatism*; but, in the latter disease, iodide of potassium is more frequently employed. *As an antidote in poisoning by strychnia, brucia*, and *veratria*, iodine has been recommended by M. Donné,[8] because the compound formed by the union of these alkalies with iodine is less active than the alkalies themselves; *as an injection for the cure of hydrocele*, Velpeau[1] has employed a mixture of the tincture of iodine with water, in the proportion of from one to two drachms of the tincture to an ounce of water: of this mixture from one to four ounces are to be injected and immediately withdrawn; lastly, to *check mercurial salivation* iodine has been successfully used.[2]

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[1] *London Medical Gazette*, vol. viii. p. 157.

[2] *Op. cit.*

[3] *London Medical Gazette*, vol. xi. p. 249.

[4] *Medico-Chirurg. Trans.* vol. xix.

[5] Cogswell's *Essay*, p. 81.

[6] *Ibid.*

[7] *London Medical Gazette*, vol. vi. p. 512, 1830.

[8] *Journ de Chim. Méd.* tom. v. p. 494.

λ. As *a topical remedy* iodine is exceedingly valuable in several classes of diseases. Dr. Davies,[3] of Hertford, has drawn the attention of the profession to its employment in this way, and pointed out the great benefit attending it. In most cases the tincture is the preparation employed. The part affected is painted with this liquid by means of a camel's-hair pencil. In some few cases only, where the skin is very delicate, will it be necessary to dilute the preparation. When it is required to remove the stain which its use gives rise to, a poultice or gruel should be applied. In *lupus* it proves highly beneficial. My attention was first drawn to its efficacy in this disease by my colleague Mr. Luke. Under its employment the process of ulceration is generally stopped, and cicatrization takes place. The tincture should be applied not only to the ulcerated portion, but to the parts around. In *eczema* it also is an excellent application. In *cutaneous scrofula,* likewise, as I have already remarked. In several other cutaneous diseases, such as *lichen, prurigo, pityriasis, psoriasis, impetigo, porrigo, ecthyma,* and *scabies,* Dr. Kennedy[4] has found its use beneficial. According to the testimony of Dr. Davies and an anonymous writer,[5] it is a valuable application to *chilblains.* In the treatment of *diseases of the joints* it is used with great advantage. In *erysipelas* I have seen it highly beneficial. In *phlegmonous inflammation, sloughing of the cellular membrane, inflammation of the absorbents, gout, carbuncle, whitlow, lacerated, contused* and *punctured wounds,* and *burns* and *scalds,* it is most highly spoken of by Dr. Davies. In *acute rheumatism* and *gout* the application of iodine to the affected parts gives unquestionable relief. Either tincture of iodine or iodine paint (to be described presently) should be applied to the affected joints by means of a camel's-hair pencil, and repeated daily until the cuticle begins to peel off. According to my experience, no remedy gives so much relief as this: I have rarely found it fail. It deserves, however, especial notice, that the skin of different invalids is most unequally susceptible of its influence: in some few it excites so much pain that a second application of it is with difficulty permitted. In others, however, it produces scarcely any painful effects.

In *diseases of the lungs and bronchial tubes* simulating phthisis, and also in incipient protracted phthisis, it may be applied to the outside of the thorax with great benefit. It is usually a much less painful application than emetic tartar or croton oil, though, as I believe, equally effective.

Its topical uses are, therefore, nearly as extensive as those of nitrate of silver. Moreover, it is used very much in the same classes of cases, and with the same views.

ADMINISTRATION.—Iodine is rarely administered alone, but generally in conjunction with *iodide of potassium*, to the account of which substance I must refer for formulæ for the combined exhibition of these substances.

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[1] *London Medical Gazette*, vol. xx. p. 90.

[2] *Ibid.* vol. xiii. p. 32; and vol. xx. p. 144.

[3] *Selections in Pathology and Surgery*, Lond. 1839.

[4] *London Medical Gazette*, vol. xxvi. [May 8, 1840], p. 260.

[5] *Ibid.* vol. xxv. [March 20, 1840], p. 943.

In the administration of iodine, care should be taken to avoid gastric irritation. On this account we should avoid giving it on an empty stomach. Exhibited immediately after a meal, its topical action is considerably diminished. This is especially the case when amylaceous substances (as potatoes, bread-pudding, sago, tapioca, and arrow-root) have been taken, as the iodine forms with them an iodide of starch. Iodine has been given in the form of pills, in substance, in doses of about half a grain; but this mode of exhibition is objectionable, and is now never resorted to.

1. **TINCTURA IODINII**, D. *Tinctura Iodinei*, E—*Tincture of Iodine.* (Iodine, ℈ij.; Rect. Spirit, ℥j. [by weight], D.—The Edinburgh College orders Iodine, ℥ijss.; Rect. Spirit, two pints.) Principally valuable as a topical remedy. For this purpose it is applied as a paint by a camel's-hair pencil. It is also used, mixed with four or six parts of soap liniment, as an embrocation. For internal exhibition it is inferior to the *Tinctura Iodinii composita*, L: hereafter to be mentioned. In the first place, by keeping, part of the iodine is deposited in a crystalline form, so that the strength is apt to vary; secondly, it undergoes decomposition, especially when exposed to solar light; the iodine abstracts hydrogen from the spirit, and forms hydriodic acid, one part of which unites with iodine to form ioduretted hydriodic acid, while another, acting on some spirit, forms a little hydriodic ether.[1] These are not the only objections: when added to water, the iodine is deposited in a solid state, and may thus irritate the stomach.

Herzog[2] gives the following directions for testing tincture of iodine:—Shake it with an excess of copper filings until it is totally decolorized: the increase of weight which the copper acquires indicates the quantity of iodine. The filtered liquor contains an acid, but no copper; and the decomposition which the tincture has undergone may be judged of by the odour and acid reaction. Calomel produces a yellowish white precipitate, which subsequently becomes red. Ammoniacal nitrate of silver yields a yellowish white precipitate, which becomes grey under water.

The dose of the tincture of iodine is ♏v. to fʒss. Each drachm of the Dublin tincture contains five grains of iodine. The best mode of exhibiting it, to cover the flavour, is in sherry wine. When this is inadmissible, sugared water may be employed.

If caustic potash be added to tincture of iodine, the solution becomes colourless, and, after some time, deposits the yellow iodide of formyle (iodoform = FoI^3 or C^2HI^3 or C^2HI,I^2), sometimes called *iodide of carbon.*

2. **EMBROCATIO IODINII**; *Iodine Paint.*—This is a solution of iodine and iodide of potassium in alcohol: the iodide of potassium greatly facilitates the solution of the iodine. The following is Dr. Todd's[3] formula for it:—Iodinii, gr. lxiv.; Potassii, Iodidi, gr. xxx.; Alcohol, ℥j. M.—"The mode of application is by painting the part freely with a camel's-hair pencil. More or less smarting is produced, and frequently vesication or an herpetic eruption may come on. The painting may be repeated as often as circumstances may demand. It is extremely useful where any effusion has taken place into synovial membranes or sheaths."

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[1] Guibourt, *Pharmaceutical Journal*, vol. vi. p. 184.

[2] *Pharmaceutical Journal*, vol. iv. p. 569.

[3] *Practical Remarks on Gout, Rheumatic Fever, and Chronic Rheumatism of the Joints*, pp. 187-88, Lond. 1843.

3. **IODIDUM AMYLI**, Ph. Ruth.; *Iodide of Starch.*—The following is Dr. Buchanan's[1] formula for preparing this substance:—Rub 24 grs. of iodine with a little water, and gradually add one ounce of finely-powdered starch; dry by a gentle heat, and preserve the powder in a well-stoppered vessel." In persons not labouring under any dyspeptic ailment or constitutional delicacy of habit, Dr. Buchanan commences with half an ounce for a dose, and increases this to an ounce, three times a day,—equivalent to about 72 grains of iodine daily. It frequently caused costiveness, attended with griping pains of the bowels and pale-coloured evacuations. Sometimes, though rarely, it produced purging. The dose is ʒss. gradually and cautiously increased. I have found the colour of this preparation objected to by patients.

4. **UNGUENTUM IODINII**, D.; *Iodine Ointment.* (Iodine, ℈j.; Prepared Hog's Lard, ℥j.)—This ointment has a rich orange-brown colour; but by keeping it becomes pale on the surface (partly by the evaporation of the iodine), and hence should always be made when wanted. It is employed as a local application to scrofulous tumors, bronchocele, &c. If it prove too irritating, the quantity of lard should be augmented.

5. **EMPLASTRUM IODINII**; *Iodine Plaster.*—Several formulæ for the preparation of an iodine plaster have been published. Of all of them lead plaster is a constituent; and the product, consequently, contains iodide of lead. The following are some formulæ:—

1. *Emplastrum Iodinii.*—Lead Plaster, ʒvj.; Resin Plaster, ʒij. Melt together, and add Iodine, ℈j. rubbed with Olive Oil, ʒss. (Beasley.)
2. *Emplastrum Iodinii* (Roderburg's).—Take ʒss. of Iodine (or ʒj. of Iodide of Potassium), rubbed with a few drops of Spirit and Olive Oil, and incorporated with ℥j. of Simple Plaster previously melted. (Beasley.)
3. *Emplastrum Iodinii Compositum*, Ph. Nosoc. Sancti Georgii.—Iodine, ʒij.; Iodide of Potassium, ʒiij.; Lead Plaster, lbj.; Opium Plaster, ℥vj. Melt the plasters, then add the iodine and iodide reduced to a very fine powder, and mix.
4. *Emplastrum Iodinii cum Belladonnâ.*—Iodine, ℥ss. to ℥ij.; Venice Turpentine, ʒij.; Olive Oil, ʒj.; Belladonna Plaster, lbj. Mix and spread with a cool iron. (Beasley.)

ANTIDOTES.—In the event of poisoning by iodine, or its tincture, the first object is to evacuate the poison from the stomach. For this purpose, the vomitings are to be assisted by the copious use of tepid demulcent liquids, especially by those containing amylaceous matter; as starch, wheaten flour, potatoes, sago, or arrow-root, which should be boiled in water, and exhibited freely (see *ante*, p. 161). The efficacy of these agents depends on their combining with the iodine to form iodide of starch, which has very little local action. In their absence, other demulcents, such as milk, eggs beat up with water, or even tepid water merely, may be given to produce vomiting. Magnesia is also recommended. Opiates have been found useful. Of course the gastro-enteritis must be combated by the usual means.

19. Acidum Iodicum.—Iodic Acid.

Formula IO^5. *Equivalent Weight* 166.

Oxiodine. Obtained by boiling iodine with nitric acid; or by decomposing iodate of baryta[2] by dilute sulphuric acid. Iodic acid is a white transparent solid, slightly deliquescent, and very soluble in water. It is composed of iodine 126 and oxygen 40. It is deoxidized by sulphuretted hydrogen, sulphurous acid, and morphia: iodine being set free in each case (hence iodic acid is used as a test for morphia). The iodates, when heated, evolve oxygen, and are converted into iodides. A solution of an iodide causes, with nitrate of silver, a whitish precipitate, which is difficultly soluble in nitric acid, but soluble in ammonia. It has been employed in medicine by Mr. Monks,[1] the house-surgeon to the Poor-law Schools, Norwood. He gives it in combination with disulphate of quina (which is rendered soluble by it as by sulphuric acid) as a tonic, stimulant, and alterative, in hoarseness consequent on catarrh, strumous cases, incipient phthisis, chronic inflammation, syphilis, &c. Unlike iodide of potassium, it can be given in combination with sulphuric or nitric acid without suffering decomposition. The dose of it for children of from 7 to 14 years of age is three grains; for adults, from three to six or more grains. Its general effects on the system agree with those of iodine.

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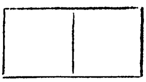
[1] *London Medical Gazette*, vol. xviii. p. 515

[2] *Iodate of baryta* is prepared by heating together 80 parts of iodine, 75 of chlorate of potash,

20. Acidum Hydriodicum.—Hydriodic Acid.

Formula HI. *Equivalent Weight* 127. *Equivalent of the Gas* 2 or 

Iodhydric acid; hydriod.—Obtained in the gaseous form by the action of water on iodide of phosphorus. Like gaseous hydrochloric acid, this gas fumes in the air. By its reaction on bases (metallic oxides), it yields water and iodides (see ante, p. 386). As a medicine, it has been employed in the form of an aqueous solution, which is directed by Dr. Buchanan[2] to be prepared as follows:—Dissolve 330 grs. of Iodide of Potassium in ℥iss. of Distilled Water, and to this add 264 grs. of Tartaric Acid, also dissolved in ℥iss. of Distilled Water. When the Bitartrate of Potash has subsided, strain; and to the strained liquor add sufficient water to make fifty drachms (=f℥vj. ʒij.) $KI+\overline{T}+2HO = KO,HO,\overline{T}+HI$. This solution, according to Dr. Buchanan, possesses all the therapeutical powers of iodine, without its irritating properties. He has given as much as ℥j. of it three times a day, or ʒij. of iodine daily. He regards ℥ss. as the ordinary dose; but it would be much safer to begin with a smaller dose.

21. SULPHURIS IODIDUM.—IODIDE OF SULPHUR.

Formula S^2I. *Equivalent Weight* 158.

HISTORY.—This compound was first described by Gay-Lussac.[3]

PREPARATION.—It is prepared by heating gently, in a clean oil flask, four parts of iodine with one part of sulphur until fusion is effected. Part of the iodine volatilizes, and the remainder unites with the sulphur.

PROPERTIES.—It is a black crystallizable compound, having the colour and radiated appearance of sesquisulphuret of antimony. It has the odour of iodine, and stains the cuticle, paper, &c. like this substance. Its elements are easily separated by heat.

Characteristics.—Boiled in water, the iodine volatilizes with the steam, and the sulphur is deposited nearly in a state of purity.

COMPOSITION.—Its composition has not been determined. It is probably the following:—

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1 of nitric acid, and 400 of water: the iodine disappears, chlorine is evolved, and iodate of potash formed in solution. The latter is decomposed by 90 parts of nitrate of baryta (or 72 parts of chloride of barium), by which iodate of baryta is precipitated.

[1] *Medical Times*, October 3, 1846.

[2] *London Medical Gazette*, vol. xviii. p. 51.

[3] *Ann. de Chimie*, xci. 22, 1814.

	Atoms.	*Eq. Wt.*	*Per Cent.*
Iodine	1	126	79·75
Sulphur	2	32	20·25
Iodide of sulphur	1	158	100·00

PHYSIOLOGICAL EFFECTS. *a. On Animals.*—Dr. Cogswell[1] gave three drachms to a bitch. The animal lost her appetite, was dull, and, on the fourth day, could not support herself properly upon her legs. On the twelfth day she was well.

β. On Man.—Its constitutional effects are probably like those of iodine. Its local operation is that of a powerful irritant and resolvent.

USES.—Iodide of sulphur has been principally employed in the form of ointment, in various skin diseases, especially the squamous and tubercular forms. In *lupus* it has been found most efficacious by Biett,[2] as well as Rayer.[3] The last-mentioned writer places it in the foremost rank of local remedies for this disease. In *acne indurata* and *rosacea* it has proved highly useful in the hands of Biett,[4] Rayer,[5] and Dr. Copland.[6] In *lepra*, Rayer has observed good effects from its use; but in one case in which I tried it, it caused so much irritation, that its use was obliged to be discontinued. In *herpes pustulosus labialis* it has been employed with great success by Dr. Volmar.[7] In *tinea capitis* it has also been recommended.[8] In chronic *eczema* of the ears an ointment of it has been used.

Dr. Copland[9] has employed the inhalation of the vapour of this substance in humoral asthma with temporary advantage.

Galtier gave internally from gr. j. to gr. vj. daily, in the form of pill.

UNGUENTUM SULPHURIS IODIDI; *Ointment of Iodide of Sulphur.*—This is composed of iodide of sulphur and lard. The proportions vary according to circumstances; usually from 10 to 30, or even to 60 grains of the iodide to an ounce of lard or cocoa-nut fat. Magendie recommends 1 part of iodide to 18 or 19 of lard.

22. Iodinii Chloridum.—Chloride of Iodine.

Two compounds of iodine and chlorine are known, viz. the *protochloride* ICl, a reddish-brown liquid,—and the *perchloride* ICl^3, a solid yellow substance. Both are obtained by exposing iodine to the action of chlorine. Dr. Turnbull[10] tried the effects of the vapour of the "chloruret of iodine" (protochloride?), on the eye: it produced very little warmth or uneasiness to the eye when continued for the space of two minutes or upwards; but a sensation of irritation, accompanied with a flow of tears, on its removal. It contracted the pupil. Its vapour did not leave the yellow disagreeable colouring on the skin produced by the vapour of iodine.

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[1] *Experimental Essay on Iodine and its Compounds.*

[2] Cazenove and Schedel, *Abrégé pratiq. sur les Malad. de la Peau.*

[3] *Treatise on Diseases of the Skin*, translated by Dr. Willis.

[4] *Op. cit.*

[5] *Op. cit.* p. 476.

[6] *Dict. of Pract. Med.* art. *Acne*, p. 31.

[7] Dierbach, *Die neuesten Entdeck in d. Mat. Med.* 2te Ausg. 1er Bd. S. 449.

[8] *London Medical Gazette*, vol. xx. p. 879.

[9] *Op. cit.* art. *Asthma*, p. 149.

[10] *London Medical Gazette*, Nov. 5, 1842.

ORDER IX. BROMINE.

23. BROMINIUM.—BROMINE.

Symbol Br. *Equivalent Weight* 80.[1] *Equivalent Volume of the Vapour* 1 or □

HISTORY.—This substance was discovered by M. Balard, of Montpellier, in 1826. He at first termed it *muride* (from *muria,* brine), in allusion to the substance from whence he procured it; but, at the suggestion of Gay-Lussac, he altered this name to that of *brome,* or *bromine* (from *βρῶμος, a stink*), on account of its unpleasant odour.

NATURAL HISTORY.—It is found in both kingdoms of nature, but never in the free state.

α. IN THE INORGANISED KINGDOM.—Bromide of silver has been found in Mexico (Berthier). Hollander detected brome in an ore of zinc, and Cochler recognised it in Silesian cadmium.[2] It exists in sea water and many mineral waters, especially brine springs, in combination with either sodium, magnesium, or calcium. Thus it has been found in the waters of the Mediterranean, the Baltic, the North Sea, the Frith of Forth, the Dead Sea, many of the brine springs of Europe and America (as those of Middlewich, Nantwich, Ashby-de-la-Zouch, and Shirleywich, in England), and in many other mineral springs of Europe and America (as the Pittville spring at Cheltenham, the water of Llandridod and of Bonnington). The saline springs near Kreuznach in Germany are especially rich in it. It has been justly observed by Dr. Daubeny,[3] that the detection of bromine in brine-springs is a fact interesting in a geological point of view, as tending to identify the product of the ancient seas, in their most minute particulars, with those of the present ocean.

β. IN THE ORGANISED KINGDOM.—Bromine has been found in the sea-plants of the Mediterranean, and in the mother-waters of Kelp. It has likewise been detected in various marine animals. Thus in the Sea-Sponge (*Spongia officinalis*), in the stony concretion found in this animal, in the ashes of the *Janthina violacea,* one of the gasteropodous mollusca, and in cod-liver oil.

PREPARATION.—Bromine is obtained from *bittern* (the mother-liquor of sea-water, from which chloride of sodium has been separated by crystallization); from kelp; or from the mother-ley of the salt springs near Kreuznach, in Germany. From thirty pounds of the concentrated ley, Liebig obtained twenty ounces of bromine. Of these springs, that of Karshall contains, according to Dr. G. Osann,[4] 6·6025 grs. of bromide of calcium, and 1·3672 grs. of bromide of magnesium, in sixteen ounces of the water. According to the same authority, 100 parts of the mother-ley of the Münster-am-Stein spring contains 24·12 parts of bromide of calcium, and 0·48 parts of bromide of magnesium. Sixteen ounces of the mother-ley of the Theodorshall spring contain 338·72 grs. of bromide of calcium, and 92·82 grs. of bromide of magnesium.

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[1] The atomic weight of bromine, according to Berzelius, is 78·4 [78·26 Graham]. This number has been usually pretty closely adhered to by chemical writers, and is adopted by the learned L. Gmelin in the first part of his *Handbuch.* But the later researches of Marignac appear to prove that about 80 is the real number; and accordingly L. Gmelin has adopted this in the second or organic part of his *Handbuch.* It is remarkable, that 80 is the number adopted by Thomson (*System of Chemistry,* 7th edit. vol. i. 1831) seventeen years since.

[2] Gmelin, *Handbuch der Chemie.*

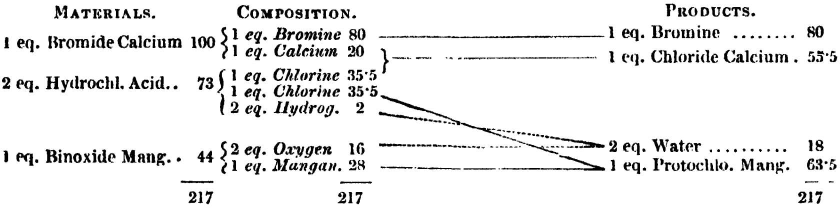
[3] *Phil. Trans.* 1830.

[4] G. W. Schwartze's *Allgemeine und specielle Heilquellenlehre,* Abt. 1, S. 224, Leipzig, 1839.

Bromine is thus obtained from bittern:—Having deprived the mother-liquor of sea-water, as much as possible, of its other salts, by crystallization, chlorine is developed in it (either by binoxide of manganese and hydrochloric acid; or, when the quantity of metallic chloride is sufficient, by binoxide of manganese and sulphuric acid). This decomposes the metallic bromide (magnesium) contained in the liquor, and sets free bromine, which distils over: $MgBr + Cl = MgCl + Br$. The bromine thus obtained requires to be subsequently purified.

The process followed at Kreuznach, according to Dr. Mohr,[1] is that recommended by Defosses,[2] but modified by Löwig.[3] To about four quarts of the mother-ley contained in a retort are added one ounce of binoxide of manganese, and five or six ounces of commercial hydrochloric acid. On the application of the heat of a sand bath, water and bromine pass over into the receiver. When all has passed over, the vapour is observed to be colourless, and to consist of aqueous vapour, and hydrochloric acid.

The following is the theory of the process:—Two equivalents of hydrochloric acid react on one equivalent of binoxide of manganese, and yield one equivalent of protochloride of manganese, two equivalents of water, and one equivalent of chlorine; the latter, in its nascent state, reacts on one equivalent of bromide of calcium, and produces one equivalent of chloride of calcium, and one equivalent of free bromine. $CaBr + MnO^2 + 2HCl = CaCl + MnCl + 2HO + Br$.



MATERIALS.		COMPOSITION.		PRODUCTS.	
1 eq. Bromide Calcium	100	1 *eq. Bromine*	80	1 eq. Bromine	80
		1 *eq. Calcium*	20	1 eq. Chloride Calcium .	55·5
2 eq. Hydrochl. Acid..	73	1 *eq. Chlorine*	35·5		
		1 *eq. Chlorine*	35·5		
		2 *eq. Hydrog.*	2		
1 eq. Binoxide Mang..	44	2 *eq. Oxygen*	16	2 eq. Water	18
		1 *eq. Mangan.*	28	1 eq. Protochlo. Mang.	63·5
	217		217		217

The mixture of binoxide of manganese and hydrochloric acid is rendered too dilute by the mother-ley to produce, by their reaction, free chlorine, when no bromide is present with whose base it can combine. Hence, when all the bromine has passed over, we find hydrochloric acid, and not chlorine, in the vapour which is passing over.

PROPERTIES.—At ordinary temperatures, bromine is a dark-coloured very volatile liquid, which, seen by reflected light, appears blackish red, but viewed in thin layers, by transmitted light, is hyacinth red. Its odour is strong and unpleasant, its taste acrid. Its sp. gr. is 2·966, Balard (2·98 to 2·99, Löwig), water being 1. When exposed to a cold of −4° F. (−13° F. Liebig) it is a yellowish brown, brittle, crystalline solid. At ordinary temperatures, liquid bromine evolves ruddy vapours (similar to those of nitrous acid), so that a few drops put into a small vessel immediately fills it with the vapour of bromine. At 116½° F. bromine boils. The vapour is not combustible: a lighted taper plunged into it is immediately extinguished; but before the flame goes out, it becomes red at the upper and green at the lower part. Antimony or arsenicum take fire when dropped into liquid bromine; when potassium or phosphorus is dropped in, a violent explosion takes place. Bromine is a non-conductor of electricity; it is a bleaching agent; it dissolves in about 34 parts of water (*bromine water*), more so in alcohol, and much more so in sulphuric ether. It communicates a fine orange colour to starch.

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[1] *Annalen der Pharmacie*, Bd. xxii. S. 66, Heidelberg, 1837.
[2] *Journ. de Chim. Méd.* t. iii. p. 256, 1827.
[3] *Das Brom und seine chemischen Verhältnisse*, Heidelberg, 1829.

Characteristics.—Liquid bromine is recognised by its colour, odour, volatility, and the colour of its vapour. To these characters must be added, its powerful action on antimony, arsenicum, and potassium, before mentioned, its dissolving in ether, forming a hyacinth red liquid, and the orange colour which it communicates to starch. It causes a yellowish white precipitate (*bromide of silver*) with a solution of the nitrate of silver. In its external appearance it resembles the terchloride of chromium and the chloride of iodine. I have known it confounded with tincture of iodine.

The soluble *bromides* cause white precipitates with the nitrate of silver, acetate of lead, and protonitrate of mercury. The precipitates are bromides of the respective metals. Bromide of silver is yellowish white, clotty, insoluble, or nearly so, in boiling nitric acid, and in a weak solution of ammonia (by which it is distinguished from chloride of silver), but dissolves in a concentrated solution of this alkali. Bromine is liberated from bromide of silver by the action of hydrochloric acid and chloride of lime. Heated with sulphuric acid, it evolves vapours of bromine. If a few drops of a solution of chlorine be added to a solution of a bromide, and then a little sulphuric ether, we obtain an ethereal solution of bromine of a hyacinth red colour, which floats on the water.

The *bromates* when heated evolve oxygen, and become bromides. The bromates cause white precipitates (*metallic bromates*) with the nitrate of silver and the protosalts of mercury. Bromate of silver is not soluble in nitric acid, but dissolves readily in solution of ammonia. If a few drops of hydrochloric acid be added to a bromate, and then some ether, a yellow or red ethereal solution of bromine is obtained.

IMPURITIES.—Water, chlorine, and iodine, are the substances with which the bromine of commerce is apt to be contaminated. Bromine is usually kept in the shops under a layer of water, for the purpose of preventing loss by evaporation. To obtain anhydrous bromine (which is rarely required), ordinary bromine must be distilled from fused chloride of calcium. The compound of chlorine and bromine is soluble in water; but repeated washing with water will only in part abstract the chlorine with which bromine is combined.

PHYSIOLOGICAL EFFECTS. α. *On Vegetables.*—I am unacquainted with any experiments made with bromine on plants.

β. *On Animals generally.*—The action of bromine on animals has been examined by Franz,[1] by Barthez, by Butzke,[2] by Dieffenbach,[3] and by Glover.[4] The animals experimented on were leeches, fishes, birds, horses, rabbits, and dogs. It acts as a local irritant and caustic, and, therefore, when swallowed, gives rise to gastro-enteritis. Injected into the jugular vein it coagulates the blood and causes immediate death, preceded by tetanic convulsions. No positive inferences can be drawn as to the specific influence of bromine on any organs of the body. Some of the symptoms (such as dilated pupil, insensibility, and convulsions) would seem to indicate a specific affection of the brain. Franz frequently observed inflammation of the liver.

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[1] Quoted by Wibmer, *Die Wirkung d. Arzneim.* 1er Bd. S. 433; also in *Journ. Chim. Méd.* tom. v. p. 540.

[2] *De Efficacia Bromi interna experimentis illustrata*, Berol. 1829.

[3] Christison, *On Poisons*, p. 187.

[4] *Edinb. Med. and Surg. Journ.* No. 152.

γ. *On Man.*—The chemical action of bromine on the tissues has been before (p. 93) noticed. The general effects of it have also been referred to (see *ante*, p. 182). It stains the cuticle yellowish brown, and, by continued application, acts as an irritant. Its vapour is very irritating when inhaled, or applied to the mucous lining of the nose, or to the conjunctiva. Franz, by breathing the vapour, had violent cough, and a feeling of suffocation, followed by headache. Butzke swallowed a drop and a half of bromine in half an ounce of water, and experienced heat in the mouth, œsophagus, and stomach, followed by colicy pains. Two drops occasioned nausea, hiccup, and increased secretion of mucus. The irritating action of bromine on the alimentary canal is shewn by the liquid stools and diarrhœa.

The constitutional effects resulting from the continued use of bromine have not been well determined: they are probably intermediate between chlorine and iodine; but, according to Dr. Glover, more nearly related to the former than to the latter. Bromine acts in small doses as a tonic, diuretic, and resolvent.

Hitherto no cases of poisoning with it in the human subject have been seen.

Uses.—It seems to possess the same therapeutic influence as iodine, and has been administered in bronchocele, in scrofula, in diseases of the spleen, in tumors, in amenorrhœa, in eczema, and against hypertrophy of the ventricles. It is usually regarded as possessing more activity than iodine. Löwig has used it as a disinfectant.

Administration.—It may be administered dissolved in water. An aqueous solution, composed of one part by weight of bromine and forty parts of water, may be given in doses of five or six drops, properly diluted and flavoured with syrup. This solution has also been used as an external agent in lotions. It has been used also in the form of ointment, composed of 10 to 15 grs. to ʒj. of lard. (For other formulæ, see *Bromide of Potassium.*)

Antidotes.—The treatment of cases of poisoning by bromine should be the same as for poisoning by iodine. Barthez has recommended magnesia as an antidote.

Order X. NITROGEN AND ITS COMPOUNDS WITH OXYGEN AND HYDROGEN.

24. Nitrogenium.—Nitrogen.

Symbol N. *Equivalent Weight* 14. *Equivalent Volume* 1 or □

This gas was first recognised, in 1772, by Dr. Rutherford, who termed it *mephitic air*. Priestley called it *phlogisticated air*. Lavoisier named it *azote* (from *a*, *not*; and ζωή, *life*). Cavendish, finding it to be a constituent of nitric acid, gave it the appellation it now usually bears, *nitrogen* (from νίτρον, *nitre*; and γεννάω, *I beget* or *produce*).

It is found in both kingdoms of nature. It has not hitherto been found in non-fossiliferous rocks; but it is a constituent of coal, of nitrates, of ammoniacal salts, and of some mineral waters. It forms from 79 to 80 per cent. of the atmosphere. It is a constituent of various organic principles (as the alkaloids, albuminous principles, gelatine, mucus, urea, uric acid, &c.) It is found in the swimming bladders of fishes.

The readiest method of procuring it is to burn a piece of phosphorus in a confined portion of atmospheric air. The phosphorus combines with the oxygen of the air and forms metaphosphoric acid. The residual gas, after being thoroughly washed, is nearly pure nitrogen.

It is a colourless, odourless, tasteless gas; is without action on vegetable colours; and is neither combustible nor a supporter of combustion. It does not whiten lime water. Its sp. gr. is 0·971. It is very slightly absorbed by water. It is usually distinguished by its negative properties just described.

In organic analysis the nitrogen is estimated either in the free state, as gas, or, by Will and Varrentrapp's method, in the form of ammonia. If an organic substance containing nitrogen be heated with a mixture of caustic soda and quicklime, the nitrogen is evolved in the form of ammonia.

The effects of nitrogen gas on vegetables and animals are analogous to those of hydrogen before mentioned (see *ante*, p. 273). Thus, when inspired, it acts as an asphyxiating agent, by excluding oxygen; when injected into the blood it acts mechanically only. It is an essential constituent of the air employed in respiration.

It has been mixed with atmospheric air, and inspired in certain pulmonary affections, with the view of diminishing the stimulant influence of the oxygen, and thereby of acting as a sedative.

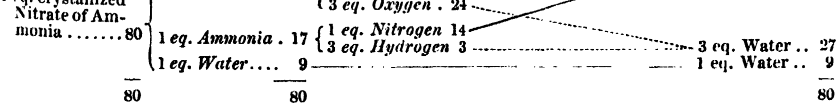
25. NITROGENII PROTOXYDUM.—PROTOXIDE OF NITROGEN.

Formula NO. *Equivalent Weight* 22. *Equivalent Volume* 1 or □

HISTORY.—This gas was discovered by Dr. Priestley in 1776. He termed it *dephlogisticated nitrous air*. Sir H. Davy[1] called it *nitrous oxide*. Its common name is *laughing gas*. It is always an artificial product.

PREPARATION.—It is obtained by heating nitrate of ammonia in a glass retort. The heat employed should be sufficient to fuse the salt and keep it in a state of gentle ebullition. If the heat be too high, white fumes are evolved.

Every equivalent of the crystallized salt is resolved into four equivalents of water and two equivalents of protoxide of nitrogen, $NH^3,HO,NO^5 = 2NO+4HO$.



If we regard the crystallized salt as a nitrate of ammonium, the equation is as follows:—$NH^4O,NO^5 = 2NO+4HO$.

1 lb. avoirdupois (=7000 grs. troy) of nitrate of ammonia should evolve about 4½ cubic feet of gas.

PROPERTIES. *a. Of the gaseous oxide.*—At ordinary temperatures and pressure, it is a colourless gas, with a faint, not disagreeable odour, and a sweetish taste. It is not combustible, but is a powerful supporter of combustion, almost rivalling in this respect oxygen gas. It does not affect vegetable colours, and undergoes no change either of colour or of volume when mixed with oxygen or binoxide of nitrogen. Its sp. gr. is 1·52.

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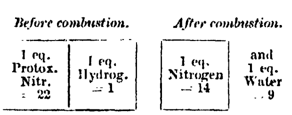
[1] *Researches, Chemical and Philosophical, chiefly concerning Nitrous Oxide, or Dephlogisticated Nitrous Air, and its Respiration*, 1800.

β. *Of the liquid oxide.*—When subjected to a pressure of 50 atmospheres, at 45° F., it is condensed into a limpid colourless, very volatile, liquid, which does not freeze itself by evaporation as liquid carbonic acid does.

γ. *Of the solid oxide.*—At a temperature of about −150° F., Faraday succeeded in solidifying protoxide of nitrogen. In this form, it is a clear, crystalline, colourless body.

Characteristics.—The only gas with which it is possible to confound it is oxygen, with which it agrees in being colourless, not combustible, but a powerful supporter of combustion, re-inflaming a glowing match. From this it may be readily distinguished by its not yielding ruddy vapours (*nitrous acid gas*) when binoxide of nitrogen is mingled with it; and by mixing it with an equal volume of hydrogen, and exploding it by the electric spark, by which we obtain one volume of nitrogen and an equivalent of water. If a taper be burnt in a jar of this gas over water, the flame is surrounded with a purplish halo, and there is produced a brown vapour (*nitrous acid gas*).



IMPURITIES.—The gas may be rendered impure by the use either of an impure nitrate or of too high a temperature. If the nitrate contain sal ammoniac, chlorine is disengaged: this may be detected by its odour and by its action on nitrate of silver (see *ante*, p. 369). If too high a temperature be employed in the preparation of the salt (and which may be known by the evolution of white vapours [hyponitrite of ammonia?]), the obtained gas is irritating, and often contains binoxide of nitrogen, the presence of which is known by the red fumes produced on mixing the gas with oxygen. The presence of oxygen or common air may be detected by mingling some binoxide of nitrogen with the suspected gas, when red fumes are produced.

COMPOSITION.—Its composition is as follows:—

	Atoms.	*Eq. Wt.*	*Per Cent.*	*Davy.*
Nitrogen	1	14	63·6	63·3
Oxygen	1	8	36·4	36·7
Protoxide Nitrogen	1	22	100·0	100·0

	Vol.	*Sp.gr.*
Nitrogen gas	1	0·97
Oxygen gas	0·5	0·55
Protoxide Nitrogen gas	1	1·52

PHYSIOLOGICAL EFFECTS. α. *On Vegetables.*—Germinating seeds (peas), when watered with a solution of this gas, seemed unaffected by it. Plants introduced into vessels filled with the gas mostly faded in about three days, and died shortly after.[1] But Drs. Turner and Christison did not find that it was injurious to vegetation.[2]

β. *On Animals.*—The effects of this gas on insects, annelides, mollusca, amphibials, birds, and mammals, were examined by Sir H. Davy. On all it acted as a positive poison. It produced "peculiar changes in their blood and in their organs, first connected with increased living action, but terminating in death." Slowly injected into the veins of animals, considerable quantities were found by Nysten to produce slight staggering only; larger quantities produced the same disorder of the nervous system noticed when the gas is respired.[1]

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[1] Davy's *Researches.*

[2] Christison, *On Poisons*, p. 756.

γ. *On Man.*—When inhaled, its effects on the nervous system are most remarkable: I have administered this gas to about one hundred persons, and have observed that after the respiration of it from a bladder for a few seconds, it usually causes frequent and deep inspiration, blueness of the lips and countenance, an indisposition to part with the inhaling tube, and a temporary delirium, which subsides in the course of three or four minutes. The sensations are usually pleasing. The delirium manifests itself differently in different individuals; as in some by dancing, in others by fighting, &c. In some few cases I have seen stupor produced. Singing in the ears, giddiness, and tingling sensations in the hands and feet, are sometimes experienced.

In a case mentioned by Professor Silliman, the after-effect of the gas was a complete perversion of the sense of taste for eight weeks (A. S. Taylor).

It produces a state of anæsthesia (see *ante*, p. 203) or insensibility to pain during surgical operations.[2]

Some serious after-effects on the lungs and brain have occasionally followed the inhalation of it in common experiments (A. S. Taylor).

USES.—It has been employed in some few cases only of disease. Beddoes used it in paralysis with benefit, but found it injurious to the hysterical and exquisitely sensible.[3] In a remarkable case of spasmodic asthma, related by Mr. Curtis,[4] it acted beneficially. In a second case it also gave relief. It has been employed in the treatment of melancholy.

DOSE.—For medicinal purposes one or two quarts may be inhaled daily from a bladder or pneumatic trough. Its use requires caution. The breathing-tube should have a side aperture closed with a cork, which can be removed should the patient evince an unwillingness to relinquish the tube.

AQUA NITROGENII PROTOXYDI; *Protoxide of Nitrogen Water; Aqua Azotica Oxygenata; Searle's Patent Oxygenous Aërated Water.*—At ordinary temperatures and pressures, water dissolves about three-fourths of its own bulk of protoxide of nitrogen; but by pressure the quantity may of course be augmented. The patent solution is said to contain five times its bulk of gas; or each bottle of the liquid is stated to hold a full quart of gas. Its effects on the system are not very marked. Sir H. Davy drank nearly three pints of the ordinary solution in one day, and says that it appeared to act as a diuretic; and he adds, "I imagined that it expedited digestion." Serullas[5] employed protoxide of nitrogen water (made at the ordinary temperature and pressure of the atmosphere) in the treatment of Asiatic cholera. The patients took six or eight pints within five or six hours: during the day their warmth returned, the blueness disappeared. It has also been employed to counteract the evil consequences of inebriety. The proprietor of the patent water asserts that it exhilarates, and is adapted for torpor, debility, fatigue, depression of spirits, asthma, dyspepsia, &c.; but is contraindicated in inflammatory and plethoric states of system.—Dose, six or eight ounces taken two or three times a day between meals, or as the ordinary beverage.

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[1] *Recherches*, pp. 77-8.

[2] *Account of a New Anæsthetic Agent as a substitute for Sulphuric Ether in Surgery and Midwifery*, by J. Y. Simpson, M.D., p. 16, 1847.

[3] Davy's *Researches*, p. 542.

[4] *Lancet*, vol. ii. for 1828-9.

[5] *Journ. de Chim. Méd.* t. viii. pp. 309 and 441, 1832.

26. Nitrogenii Binoxydum.—Binoxide of Nitrogen.

Formula NO^2. *Equivalent Weight* 30. *Equivalent Volume* 2 or

Nitrous gas; nitric oxide; nitrous air; deutoxide of nitrogen.—Known to Hales; but first accurately examined by Priestley in 1772. It is procured in great abundance by dissolving copper filings or clippings in nitric acid, and collecting the gas over water. $4NO^5 + 3Cu = NO^2 + 3(CuO,NO^5)$. It is a colourless gas, whose sp. gr. is 1·038. It is a supporter of combustion. It forms red fumes of hyponitric (nitrous) acid when mixed with oxygen gas or atmospheric air. $NO^2 + 2O = NO^4$. It dissolves in a solution of protosulphate of iron, to which it communicates a dark, greenish-brown, or olive colour. This compound, which is said to be definite, and to consist of $4(FeO,SO^3) + NO^2$, communicates a red or purplish colour to a large quantity of cold oil of vitriol (see *ante*, p. 356). The odour, taste, and effects of the gas, when taken into the lungs, are unknown; because, immediately an attempt is made to inhale it, it absorbs oxygen from the air, and is converted into hyponitric (nitrous) acid. Sir H. Davy rashly tried to inspire it (having previously exhausted his lungs of air by making three inspirations and expirations of protoxide of nitrogen), but the attempt fortunately failed by the production of spasm of the glottis, to which occurrence he considered he owed his life.—In pharmacy, binoxide of nitrogen is useful as a test for oxygen (see *ante*, pp. 268 and 406), and on account of its characteristic reaction on the solution of protosulphate of iron (see pp. 356 and 412).

27. ACIDUM NITRICUM.—NITRIC ACID.

Formula NO^5. *Equivalent Weight* 54.

HISTORY.—Liquid or hydrated nitric acid was known in the seventh century to Geber, who termed it *solutive water.*[1] The nature of its constituents was shewn by Cavendish in 1785, and their proportions were subsequently determined by Davy, Gay-Lussac, and Thomson. It is sometimes called *azotic acid.*

NATURAL HISTORY.—It is found in both kingdoms of nature.

a. IN THE INORGANISED KINGDOM.—Combined with potash, soda, lime, or magnesia, it is found on the surface of the earth in various parts of the world. The nitrates have been found in some few mineral waters. Thus, there is a district of Hungary, between the Carpathians and the Drave, where all the springs, for the space of about 300 miles, contain a small quantity of the nitrate of potash.[2] It is found in rain water after a thunder storm.

β. IN THE ORGANISED KINGDOM.—Nitric acid in combination with bases (potash, soda, lime, and magnesia,) is a frequent constituent of vegetable juices.[3]

PREPARATION.—Dry or uncombined nitric acid cannot be procured. It does not appear to be capable of existing in the insulated state; for when attempts are made to separate it from other bodies, it suffers decomposition.

PROPERTIES.—Unknown.

COMPOSITION.—*Anhydrous* or *dry nitric acid,* such as we find it in some nitrates, has the following composition by weight:—

	Atoms.	*Eq.Wt.*	*P. Ct.*	*Lavoisier.*	*Cav.*	*Berz.*	*Davy.*	*Vols.*		*Vols.*	
Nitrogen..	1	14	25·9	20	25	26	29·5	Nitrogen	1	Binox. Nitrogen	2
Oxygen...	5	40	74·1	80	75	74	70·5	Oxygen .	2·5	Oxygen	1·5
Nitric Acid	6	54	100·0	100	100	100	100				

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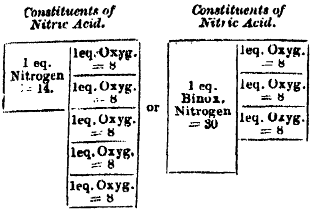
[1] *Of the Invention of Verity,* ch. xxi. and xxiii.

[2] Gairdner, *On Mineral Springs,* p. 20.

[3] De Candolle, *Physiol. Végét.* t. 1er, pp. 383, 387, and 403; also Johnston's *Lectures on Agricultural Chemistry,* 2d edit. 1847.



The degree of condensation which these ingredients suffer is unknown.

Liquid or Watery Nitric Acid.

SYNONYMES.—*Nitrate of water; [illegible]rate of nitric acid; nitric acid* (*acidum nitricum*) of the pharmacopœias and shops; *spirit of nitre* (*spiritus nitri*); *Glauber's spirit of nitre* (*spiritus nitri Glauberi*).

When liquid nitric acid is red and fuming from the presence of nitrous acid, it is called *fuming nitric acid* (*acidum nitricum fumans*), or commonly *nitrous acid* (*acidum nitrosum*).

The term *aqua fortis* (either *single* or *double*) is applied to a more dilute acid than the preceding.

PREPARATION.—Liquid nitric acid is usually obtained by submitting to distillation a nitrate (either of potash or soda), with oil of vitriol.

Formerly it was procured by submitting to distillation a mixture of nitre and either sulphate of iron or clay.[1] Mr. de Sussex has recently proposed the use of lime and a nitrate.

The London and Edinburgh Colleges use equal weights of dried nitrate of potash and sulphuric acid. The Dublin College directs 100 parts of nitrate of potash and 97 parts of commercial sulphuric acid. The distillation is to be conducted in a glass retort, by a sand heat. The directions of the Edinburgh College for obtaining pure nitric acid (*acidum nitricum purum*) are as follows:—

> "Purify nitrate of potash, if necessary, by two or more crystallizations, till nitrate of silver does not act on its solution in distilled water. Put into a glass retort equal weights of this purified nitrate and of sulphuric acid, and distil into a cool receiver, with a moderate heat from a sand-bath or naked gas-flame, so long as the fused material continues to give off vapour. The pale-yellow acid thus obtained may be rendered colourless, should this be thought necessary, by heating it gently in a retort."

Nitric acid manufacturers frequently employ nitrate of soda (sometimes called Chili saltpetre) instead of nitrate of potash in the preparation of this acid; and Knapp[2] says there are three advantages attending its use; viz. the quantity of nitric acid obtained from an equal weight of the salt is greater, the cost of the salt is less, and the nitric acid is disengaged at a lower temperature, and consequently a less coloured product is obtained.

When the object is to obtain pure nitric acid, the distillation is effected in a glass retort and receiver; but the common nitric acid of commerce is usually procured by means of an iron or stoneware still.

The apparatus used on the large scale is generally that employed in the manufacture of hydrochloric acid (see *ante*, p. 377); namely, an iron or stoneware pot, with a stoneware head, which is connected with a row of double-necked stoneware bottles containing water. Another form of apparatus employed by some manufacturers, is an iron cylinder, set in brickwork over a fire-place, and connected with a row of five or six double-necked stoneware bottles each containing about $\frac{1}{6}$th of their capacity of water.

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[1] See Quincy's *Complete English Dispensatory*, 14th edit. pp. 292-4, 1769.

[2] *Chemical Technology*, vol. i. pp. 420-1, 1848.

I was informed by a manufacturer that the charge employed for one of these cylinders was 168lbs. of nitrate of potash and 93lbs. of oil of vitriol, sp. gr. 1·485. These quantities are nearly in the proportion of eight equivalents of acid to seven equivalents of nitrate. Different manufacturers, however, employ somewhat different proportions.

The acid obtained by the process of the Pharmacopœia has a sp. gr. of 1·50; that procured by the ordinary process is brown and fuming, and has a sp. gr. of about 1·45. This is the *nitrous acid* or *fuming nitric acid* of commerce. To render it colourless it is heated in a glass retort, placed in a sand-bath. The colourless acid thus obtained has a sp. gr. of from 1·35 to about 1·4, and constitutes the *nitric acid of commerce* (*acidum nitricum venale*). The residue in the iron cylinder is a mixture of sulphate with a little bisulphate of potash, and is sold as *sal enixum*. It is employed as a flux, and in the manufacture of alum.

Theory.—The explanation of the changes which take place in the manufacture of nitric acid is somewhat modified by the strength of the sulphuric acid employed, and by the proportion of the ingredients used. Assuming the oil of vitriol employed to have a sp. gr. of 1·8433 (that is, to be composed of about four equivalents of real sulphuric acid and five equivalents of water), and that an equal weight of nitrate of potash be used, the changes which occur will be as follows: four equivalents of dry sulphuric acid, and five equivalents of water react on two equivalents of nitrate of potash, and produce two equivalents of strong liquid nitric acid (sesquihydrate) and one equivalent of hydrated bisulphate of potash. $2(KO,NO^5) + 5HO,4SO^3 = 2(KO,2SO^3) + 3HO,2NO^5$.

Materials.		Composition.		Products.	
2 eq. Nitrate Potash	202	*2 eq. Nitric Acid*	108	2 Sesquihydrate Nitric Acid	135
		2 eq. Potash	94		
4 eq. Liquid Sulphuric Acid.. (Sp. gr. 1·8433.)	205	*3 eq. Water*	27		
		2 eq. Water	18		
		4 eq. Sulph. Acid	160	2 Hyd. Bisulphate Potash..	272
	407		407		407

The generation of nitrous acid is greatest at the commencement and towards the close of the operation; for, at the commencement, the excess of uncombined sulphuric acid attracts water from the small quantity of nitric acid then set free, in consequence of which the latter is resolved into nitrous acid and oxygen; about the middle of the process, when the quantity of free nitric acid has increased, while that of the sulphuric acid has diminished, the former passes over with water unchanged; but towards the end of the process, owing to the volatilization of the nitric acid, the sulphuric acid becomes again predominant, and the red vapours of nitrous acid then make their appearance.

Properties.—Strong and pure liquid nitric acid (*acidum nitricum purum*) is colourless, and has a peculiar odour, and an acrid, intensely sour taste. In the air it evolves white fumes, formed by the union of the acid vapour with the aqueous vapour of the atmosphere; these fumes redden litmus, and become much whiter when mixed with the vapour of ammonia, owing to the formation of the nitrate of ammonia. The strongest colourless acid of the shops has a sp. gr. of 1·45; and the ordinary colourless acid does not usually exceed 1·35 to 1·4. The sp. gr. of the acid, prepared according to the Pharmacopœia, is 1·5033 to 1·504; and Mr. Phillips believes this to be the strongest procurable; but Proust says he obtained it as high as 1·62; Kirwan, 1·554; Davy, 1·55; Gay-Lussac, 1·510; Thenard, 1·513; and more recently Millon obtained it at 1·521. The Edinburgh College fixes the density of pure nitric acid at 1·500, and that of commercial acid at from 1·380 to 1·390. Acid of this density has a slight yellow tinge. At 248° F., nitric acid, of sp. gr. 1·42, boils: acid either denser or less dense than this boils at a lower temperature. At —40° F. the concentrated acid boils. Nitric acid has a powerful affinity for water; and, when mixed with it, heat is evolved.

Nitric acid is easily deoxidized. Thus, exposure to solar light causes the evolution of oxygen and the production of nitrous acid, which gives the liquid a yellow, orange, or reddish-brown colour. The acid thus coloured may be rendered colourless, but of course weaker, by the application of a gentle heat, to drive off the nitrous acid. Several of the non-metallic combustibles rapidly decompose nitric acid; as charcoal, phosphorus, sugar, alcohol, volatile oils, resins, &c. The acid is unacted on by leaf-gold, platinum, &c. Some of the metals[1] also act powerfully on it, as copper (in the form of turnings), and tin (in the state of foil). A little water added to the acid facilitates, in some cases, the action of metals on it. The hydracids (as hydrochloric acid) decompose, and are decomposed by, nitric acid.

ACIDUM NITROSO-NITRICUM; *Fuming nitric acid (acidum nitricum fumans); Spiritus nitri fumans; Nitrous acid (acidum nitrosum)* of commerce.—This is a mixture or compound of nitric and nitrous acids with some water. It may be procured by adding nitrous acid to concentrated nitric acid; or by passing binoxide of nitrogen into concentrated nitric .acid. The commercial nitrous acid is obtained by the distillation of nitrate of either soda or potash with oil of vitriol. When an equal number of atoms of nitrate of potash and strong oil of vitriol are submitted to distillation, the first products are hydrated nitric acid, bisulphate of potash, and undecomposed nitrate. $2(HO,SO^3) + 2(KO,NO^5) = HO,NO^5 + KO,HO,2SO^3 + KO,NO.^5$ At a higher temperature the bisulphate reacts on the nitrate and expels the nitric acid, which is resolved into oxygen and nitrous acid, $NO^5 = O + NO.^4$ The latter dissolves in the hydrated nitric acid and produces fuming nitric acid—the nitrous acid of the shops.

It is a coloured liquid, the colour varying with the quantity of nitrous acid which it contains: usually it is yellowish-red. It fumes in the air, and gives out a darker yellowish-red vapour (nitrous acid). The sp. gr. of the most concentrated acid is 1·536; but that of the shops varies from 1·425 to 1·450. When the strong acid is exposed to a cold of —56°·2 F. it congeals into a very dark red mass. It is a more corrosive acid than concentrated nitric acid, as it more readily gives out oxygen with the development of more heat and light. Thus it acts more violently on the metallic sulphurets than ordinary nitric acid, and is, therefore, used for the purpose of oxidizing them. By the addition of an alkali to the fuming acid, binoxide of nitrogen is evolved, and a nitrate and hyponitrite formed. If the fuming acid be gently heated in a retort, nitrous acid is evolved, and there is left behind colourless nitric acid whose density is less than that of the fuming acid.

AQUA FORTIS DUPLEX; *Double Aqua Fortis.*—This is liquid nitric acid of sp. gr. 1·36. It is used by jewellers for dissolving metals, and by colour-makers.

AQUA FORTIS SIMPLEX; *Single Aqua Fortis.*—This is liquid nitric acid of sp. gr. 1·22-1·25. It is employed principally by dyers for dissolving tin.

Characteristics.—Nitric acid is known by the following characters:—It stains the cuticle, quills, &c. yellow or orange: mixed with copper filings, effervescence takes place, owing to the escape of binoxide of nitrogen, and a greenish-blue solution of nitrate of copper is obtained: the binoxide forms ruddy vapours in the air, by uniting with oxygen to form nitrous acid gas; and, passed into a solution of the protosulphate of iron, forms a dark olive-brown coloured liquid. To the liquid suspected to contain nitric acid add at least ¼th of its volume of pure oil of vitriol; and when the mixture is cold, add protosulphate of iron, when a dark purplish or brownish colour is developed. Nitric acid decolorises sulphate of indigo. Morphia or brucia communicates a red colour to nitric acid, which is heightened by supersaturating the liquor with ammonia: powdered nux vomica renders this acid yellow or orange-coloured. If hydrochloric acid be added to nitric acid, the mixture acquires the power of dissolving leaf-gold: the presence of gold in solution may be recognised by the protochloride of tin, with which it strikes a purple or blackish colour. Lastly, saturated with pure carbonate (or bicarbonate) of potash, a nitrate of potash is procured.

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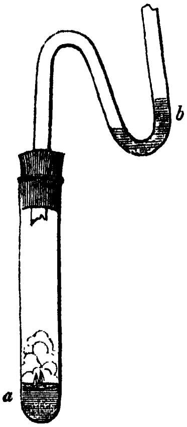
[1] For an account of the anomalous relations of this acid and iron, I must refer the reader to Becquerel's *Traité de Electricité*, tom. v. p. 8; also Brande's *Man. of Chem.* vol. i. p. 723, 1848.

The *nitrates* are known by the following characters:—They evolve oxygen when heated, and deflagrate when thrown on a red-hot cinder or charcoal; when heated with sulphuric acid they disengage nitric acid, which may be recognised by its action on morphia, brucia, or commercial strychnia; lastly, when mixed with sulphuric acid and copper-turnings, they generate binoxide of nitrogen, which is readily recognised by its blackening a solution of sulphate of the protoxide of iron. This last-mentioned property enables us to recognise very minute portions of the nitrates. The nitrate, copper-filings, and sulphuric acid, are to be put into the test-tube (fig. 71, *a*), to which is adapted, by means of a cork, a small curved glass tube, containing at the bend (*b*) a drop or two of the solution of the protosulphate of iron; heat is to be applied to the mixture in the test-tube, and in a few minutes the ferruginous solution becomes brown or blackish (see *ante*, p. 408).

Fig 71.



Apparatus for the detection of Nitric Acid.

Composition.—Liquid or watery nitric acid is composed of dry or real nitric acid and water. The strongest acid obtained by Millon was a monohydrate.

When the sp. gr. is 1·5033 to 1·504, the liquid acid is, according to Mr. Phillips, a sesquihydrate; when the sp. gr. is 1·486, the acid, according to Dr. Ure, is a binhydrate.

	Millon's strongest Acid.			Sp. gr. 1·5033 to 1·504.			Sp. gr. 1·486.			Sp. gr. 1·42.		
	Atoms.	*Eq.Wt.*	*P.Ct.*	*At.*	*Eq.Wt.*	*P.Ct.*	*At.*	*Eq.Wt.*	*P.Ct.*	*At.*	*Eq.Wt.*	*P.Ct.*
Dry Nitric Acid	1	54	85·7	1	54	80	1	54	75	1	54	60
Water	1	9	14·3	1½	13·5	20	2	18	25	4	36	40
Liquid Nitric Acid	1	63	100·0	1	67·5	100	1	72	100	1	90	100

One hundred grains of nitric acid, sp. gr. 1·5, saturate about 217 grains of carbonate of soda, equal to about 81 grains of real or dry nitric acid. This, therefore, is the strength of the nitric acid of the London Pharmacopœia.

According to Mr. Graham, acid whose sp. gr. is 1·42 is the proper nitrate of water; and of the four atoms of water which it contains, one is combined with the acid as a base and may be termed *basic* water, while the other three are in combination with the nitrate of water, and may be termed the *constitutional* water of that salt. HO,NO^5+3HO.

IMPURITIES.—The ordinary impurities of commercial nitric acid are, excess of water, nitrous acid, chlorine, and sulphuric acid.

The presence of an excess of water is detected by the low sp. gr. The presence of nitrous acid is known by the colour of the acid being yellow or orange. Its origin has been before explained (see *ante*, p. 411).

According to Millon[1], the best test for the presence of nitrous acid is an aqueous solution of sulphuretted hydrogen. If this be added to the suspected acid which has been previously diluted with once or twice its volume of water, the least trace of nitrous acid causes the liberation of sulphur, which gives an opalescent appearance to the liquor. At the same time a small quantity of ammonia is formed.

To detect chlorine (which is derived from the alkaline chlorides contained in the nitrate, and in the manufacture of nitric acid), dilute with distilled water, and apply nitrate of silver; a white chloride of silver is precipitated, which is insoluble in nitric acid but soluble in ammonia. To recognise sulphuric acid (carried over from the acid in the still or retort), add a solution of nitrate of baryta or chloride of barium to the acid previously diluted with water; a heavy white sulphate, insoluble in nitric acid, is thrown down.

When nitric acid has been obtained from Chili nitrate of soda, it is apt to be contaminated with iodine (derived from the alkaline iodide contained in the Chili nitrate) or iodic acid, formed by the oxidation of iodine. The presence of iodine is detected by starch (see *ante*, p. 386). Nitric acid coloured brownish by iodine, loses its colour by keeping, owing to the oxidation of the iodine and its conversion into iodic acid. To detect iodic acid, add sulphurous acid and starch to the diluted nitric acid: the sulphurous acid deoxidizes the iodic acid, and the starch produces a blue colour with the iodine.

The characters of pure nitric acid are, according to the London Pharmacopœia, as follows:—

By heat it wholly passes off in vapour. When mixed with distilled water, neither nitrate of silver nor chloride of barium throws down anything. Its sp. gr. is 1·50. About 217 grains of the crystals of carbonate of soda are saturated by 100 grains of this acid.

PURIFICATION.—For nitric acid whose sp. gr. does not exceed 1·48, the best method of purification is to add one part of bichromate of potash to every hundred of acid, and distil. The nitrous acid is transformed into nitric acid at the expense of the oxygen of the chromic acid.

PHYSIOLOGICAL EFFECTS. α. *On Vegetables.*—Nitric acid decomposes the different vegetable tissues to which it may be applied, and gives them a yellow colour.

β. *On Animals.*—Orfila found that 26 grains of commercial nitric acid, injected into the jugular vein, coagulated the blood, and caused death in two minutes.[2] Viborg threw a drachm of the acid, diluted with three drachms of water, into the jugular vein of two horses; in two hours they were well: the blood, when drawn, was slightly coagulated.[3] Introduced into the stomach of dogs, it disorganises this viscus, and causes death in a few hours.

γ. *On Man.*—On the *dead body*, M. Tartra has made various experiments to determine the appearances produced by the action of nitric acid. Of course this caustic decomposes the organic textures; but the phenomena presented vary according to different circumstances—as the quantity employed, the presence of other substances, &c.

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[1] *Pharmaceutical Journal*, vol. ii. p. 355.

[2] *Toxicolog. Générale.*

[3] Wibmer, *Die Wirkung*, &c.

The chemical action of nitric acid on the tissues has been already noticed (see *ante*, p. 94).

On the *living body*, its action varies with the degree of concentration or dilution of the acid. In the concentrated form the acid acts as a powerfully corrosive poison, which property it derives in part from its affinity for water, but more especially from the facility with which it gives out oxygen; so that the appearances caused by its action on some of the tissues are different from those produced by sulphuric acid. The permanent yellow stain (xantho-proteic acid) which it communicates to the cuticle is peculiar to it. Iodine stains the skin yellow or brown, but a little caustic potash readily removes the stain when recent; whereas the yellowish stain produced by nitric acid becomes orange on the addition of an alkaline soap. Bromine also stains the skin yellow; but when recently produced, the colour may also be removed by potash. The yellow or citron stain communicated to the lining membrane of the tongue, pharynx, &c. by nitric acid, has been well shewn by Dr. Roupell.[1] A preparation, presenting similar appearances, is preserved in the anatomical museum of the London Hospital. Nitric, like sulphuric, acid also chars the animal tissues; and thus, after the ingestion of it, the stomach is sometimes found blackened, as if sulphuric acid had been swallowed. The symptoms are analogous to those produced by sulphuric acid (see *ante*, p. 358). The yellow, citron, or orange spots sometimes observed on the lips, chin, or face, will, when present, at once indicate the kind of acid swallowed. Sometimes the binoxide of nitrogen is evolved by the mouth.

Properly diluted, nitric acid produces effects similar to those of the other mineral acids (see *ante*, p. 170). It is said, however, to act less evidently as a tonic, and to be more apt to disagree with the stomach, so that it cannot be employed for so long a period. In some cases it has excited ptyalism, and from this circumstance, as well as from the occasional benefit derived from its use in the venereal disease, it has by some writers been compared, in its operation, to mercury—a comparison founded rather on theoretical than practical considerations.

Uses. α. *Internal.*—As nitric acid produces certain effects, in common with other mineral acids, it may be used as a substitute for the latter in various diseases. Thus, it is administered in conjunction with the bitter infusions, in those conditions admitting of, or requiring, the use of tonics. Properly diluted, it is employed as a refrigerant in febrile disorders. In lithiasis, attended with phosphatic deposits in the urine, it has been used instead of the sulphuric or hydrochloric acid. As a lithonlytic injected into the bladder, very dilute nitric acid has been successfully employed by Sir B. Brodie (see *ante*, p. 261). In some obstinate cutaneous diseases, as impetigo, it is given to the extent of half a drachm daily in barley water.[2] It may be employed, also, to relieve heartburn.

In 1793 this acid was used by Mr. Scott, a surgeon at Bombay, as a substitute for mercurial preparations, which Girtanner erroneously fancied owed their efficacy to the quantity of oxygen which they contained. Mr. Scott first tried it in chronic hepatitis, and with considerable success. He then extended its use to venereal diseases, and obtained the happiest results from it.

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[1] See his *Illustrations of the Effects of Poisons.*

[2] Rayer, *Treatise on the Diseases of the Skin*, p. 502.

Subsequently it has been most extensively employed in the last-mentioned diseases; but the success attending its use has been variable. That it has been, and is frequently serviceable, no one can doubt who reads the immense body of evidence offered in its favour by Scott, Kellie, Albers, Prioleau, Rollo, Cruickshank, Beddoes,[1] Ferriar, and others. But, on the other hand, it is equally certain that on very many occasions it has been useless. The same remark, indeed, may be made of mercury, or of any other remedy: but as an anti-venereal medicine it does not admit of comparison with this metal. However, we frequently meet with syphilitic cases in which the employment of mercury is either useless or hurtful. Thus it can rarely be employed with advantage in scrofulous subjects; or in persons whose idiosyncrasies render them peculiarly susceptible to the influence of this metal; and in sloughing sores it is inadmissible. Now these are the cases in which nitric acid may be employed with benefit; and I believe the best mode of administering it is in conjunction with the compound decoction of sarsaparilla.

For further information respecting its employment, I must refer to the works of Holst[2] and Mr. Samuel Cooper.[3]

β. *External.*[4]—In the *concentrated* state, nitric acid has been employed as a powerful escharotic (see *ante*, p. 157); as to destroy warts, and as an application to parts bitten by rabid animals or venomous serpents, to phagedenic ulcers, &c. In order to confine the acid to the spot intended to be acted on, the neighbouring parts may be previously smeared with some resinous ointment. In sloughing phagedæna the application of strong nitric acid, as recommended by Mr. Welbank,[5] is attended with the most successful results, as I have on several occasions witnessed. The best mode of applying it is by a piece of lint tied round a small stick or skewer. When the slough is very thick, it is sometimes necessary to remove part of it with a pair of scissors, in order to enable the acid to come in contact with the living surface.

Largely *diluted* (as 50 or 60 drops of strong acid to a pint or quart of water) it is recommended by Sir Astley Cooper as a wash for sloughing and other ill-conditioned sores.

In the form of *ointment* it is used in various skin diseases, especially porrigo and scabies, and as an application to syphilitic sores.

Nitric acid vapour has been employed as a disinfectant (see *ante*, p. 162), but it is probably inferior to chlorine. It was first introduced for this purpose by Dr. Carmichael Smyth[6] (to whom Parliament granted a reward of £5000): hence these fumigations have been termed *fumigationes nitricæ Smythianæ*. The vapour is readily developed by pouring one part of oil of vitriol over one part of nitrate of potash in a saucer placed on heated sand.

ADMINISTRATION.—The dose will depend on the concentration of the acid. The usual statement in pharmacological works applies to the commercial nitric acid and to the acid of the pharmacopœia (sp. gr. 1·5). The latter is so strong that it ought not to be dispensed in small quantities, "as it is impossible to measure a few minims with so much accuracy as a proportionate quantity of the diluted acid."[1] (see *Acidum Nitricum Dilutum*).

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[1] *Reports, principally concerning the Effects of the Nitrous Acid in Venereal Disease*, Bristol, 1797.

[2] *De Acidi Nitrici Usu Medico Dissertatio*, Christianæ, 1818.

[3] *Dictionary of Practical Surgery.*

[4] On the external use of nitric acid, see *London Medical Repository*, vol. xiv. p. 450, 1820.

[5] *Medico.-Chirurg. Trans.* vol. xi.

[6] *The Effects of the Nitrous Vapour in preventing and destroying Contagion*, London, 1799: reviewed in the *London Medical Review*, vol. i. p. 433, Lond. 1779.

ANTIDOTES.—Poisoning by nitric acid requires precisely the same treatment as that by sulphuric acid (see *ante*, pp. 159, 160, and 360).

1. ACIDUM NITRICUM DILUTUM, L. E. D.—*Diluted Nitric Acid*; (Nitric Acid, f℥j.; Distilled Water, f℥ix. *L.* Pure Nitric Acid (sp. gr. 1·500) f℥j, and Distilled Water f℥ix.; or, Commercial Nitric Acid (sp. gr. 1·390) f℥j and f℥vss, and Distilled Water f℥ix. *E.* Nitric Acid, by measure, 3 parts; Distilled Water, by measure, 4 parts, *D.*)—The sp. gr. of the Diluted Nitric Acid of the London Pharmacopœia (1836) is 1·080; 100 grains of it saturate about 31 grains of crystallized carbonate of soda. The following is its composition:—

	Per Cent.		*Per Cent.*
Dry or real nitric acid	11·44	Strong liquid Nitric Acid (sesquihydrate)	14·3
Water	88·56	Water	85·7
Diluted Nitric Acid, *Ph. L.*	100·00	Diluted Nitric Acid, *Ph. L.*	100·0

The diluted nitric acid of the Edinburgh Pharmacopœia (1814) has a sp. gr. of 1·077; and it contains 11·16 of dry or real nitric acid.

The diluted nitric acid of the Dublin Pharmacopœia (1826) has a sp. gr. of 1·280; and it is more than three times stronger than that of the London and Edinburgh Pharmacopœias.

The strength of this preparation varies considerably in the shops, owing to the employment of nitric acid of different densities in its preparation. When prepared with acid whose sp. gr. is that of the Pharmacopœia (*i. e.* 1·500), its strength is almost double that prepared with the ordinary colourless nitric acid of the shops (sp. gr. 1·350).

The dose of the dilute nitric acid of the London and Edinburgh Pharmacopœias is—♏xx. to ♏xl. (equal to ♏ij. and ♏iv. of strong nitric acid).

The dose of the dilute nitric acid of the Dublin Pharmacopœia is from ♏vij. to ♏xv.

The above doses apply to the dilute nitric acid made according to the directions of the Pharmacopœias; that is, with nitric acid, sp. gr. 1·500. Much larger doses may of course be given when this preparation is made with the ordinary commercial nitric acid, sp. gr. 1·35 to 1·4.

Some useful cautions respecting the dose of properly prepared dilute nitric acid have been given by Mr. Bell.[1] Alluding to the dose of ♏xl. of the acid of the London Pharmacopœia, he says, "we have no hesitation in stating that this quantity is quite sufficient, *unless largely diluted*, to act injuriously on the enamel of the teeth;" and he mentions a case in which six minims of the strong acid (equal to f℥j. of the dilute acid), taken in an ounce of fluid three times a day, seriously injured the teeth in two or three days.

Larger doses than those above stated may be administered if properly diluted. The medicine may be taken by sucking it through a quill or glass tube, and the mouth should be rinsed with either water or an alkaline solution immediately after each dose.

2. UNGUENTUM ACIDI NITRICI, D. *Oxygenised Fat; Pommade d'Alyon.*—(Olive oil, ℔j.; Prepared Hog's-Lard, ℥iv.; Nitric Acid, by measure, ℥vss. Having melted the oil and lard in a glass vessel, when they are beginning to become concrete, add the acid; then stir them constantly with a glass rod until they become firm.) The constituents of the fatty substances suffer oxidation at the expense of the nitric acid. The changes are complicated and the products numerous (see *Unguentum Hydrargyri Nitratis*). This ointment has a firm consistence and a yellow colour. Its uses have been above noticed. It is more efficacious when recently prepared.

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[1] *Pharmaceutical Journal*, vol. iii. p. 113-14.

[2] *Ibid.* p. 113.

28. ACIDUM NITRO-HYDROCHLORICUM.—NITRO-HYDROCHLORIC ACID.

HISTORY.—This liquid was known to Geber.[1] It was formerly called *aqua regia*. It is commonly known as *nitro-muriatic acid* (*acidum nitro-muriaticum*).

PREPARATION.—It is prepared by mixing hydrochloric acid with nitric acid. The directions of the Dublin Pharmacopœia (1826) for its preparation are as follows:—

Take of Nitric Acid, by measure, one part; Muriatic Acid, by measure, two parts. Mix the acids in a refrigerated bottle, and keep the mixture in a cold and dark place.

In the arts, a solution having the power of dissolving gold is sometimes prepared by adding nitre to hydrochloric acid, or common salt or sal ammoniac to nitric acid.

The precise nature of nitro-hydrochloric acid is somewhat obscure. According to Davy,[2] by the reaction of one equivalent of nitric acid on one equivalent of hydrochloric acid, we obtain one equivalent of nitrous acid, one equivalent of chlorine, and an equivalent of water. $NO^5 + HCl = NO^4 + HO + Cl$.

MATERIALS.		COMPOSITION.		RESULTS.	
1 eq. Hydrochloric Acid ..	36·5	1 *eq. Chlorine*	35·5	1 eq. Chlorine	35·5
		1 *eq. Hydrogen*......	1	1 eq. Water	9
1 eq. Nitric Acid	54	1 *eq. Oxygen*........	8		
		1 *eq. Nitrous Acid*..	46	1 eq. Nitrous Acid..	46
	90·5		90·5		90·5

But the reaction of these substances is influenced by temperature, by the degree of concentration of the acids, and by the presence of a substance capable of combining with chlorine. Usually "the mutual decomposition of the two acids proceeds only so far as to saturate the liquid with chlorine" (Brande). If, however, heat be applied to expel the liberated chlorine, or if a metal be introduced to absorb it, the decomposition goes on until one or both of the acids are exhausted.

Mr. E Davy[3] ascribes the solvent power of aqua regia to chloro-nitrous gas (NO^2Cl^2) dissolved in the liquid. This gas is produced by the mutual reaction of nitric acid and common salt. $4NO^5 + 3NaCl = 3(NaO,NO^5) + Cl + NO^2Cl^2$.

Baudrimont,[4] on the other hand, states that by the mutual action of nitric and hydrochloric acids, *chloro-nitric* (*chloro-azotic*) *acid* is produced, which is the effective solvent of the mixture. $NO^5+2HCl=NO^3Cl+2HO$. This view, however, has been contested by Koene.[1]

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[1] *Invention of Verity*, chap. xxiii.

[2] *Journal of Science and the Arts*, vol. i. p. 67, 1816.

[3] *Phil. Mag.* vol. ix. p. 355.

[4] *Journal de Pharmacie*, 3me ser. tom. v. p. 49, 1844.

PROPERTIES.—It has a yellow colour. Its most remarkable property is that of dissolving gold and platinum, metals that are insoluble in either nitric or hydrochloric acid separately. It should be kept in a cool dark place; for heat rapidly expels the chlorine, while light enables it to decompose the water and to form hydrochloric acid.

Characteristics.—It is recognised by its colour, by its power of dissolving gold, by its precipitating a solution of the nitrate of silver, the precipitate being insoluble in nitric acid, but soluble in ammonia; by the production of two salts, a chloride and a nitrate, when an alkali is added to it; and by the evolution of binoxide of nitrogen on the addition of copper turnings.

PHYSIOLOGICAL EFFECTS.—It is a powerfully corrosive poison, acting in a similar manner to nitric acid.

USES.—It has been employed *internally* in the same cases as nitric acid, more especially in syphilis, diseases of the liver, and some of the exanthemata. *Externally* it has been used as a bath, either local or general, in syphilis and hepatic affections. Dr. Lendrick[2] has more recently noticed the utility of the general nitro-muriatic bath, at a temperature of 90° or 95°, in syphiloid and mercurial cachexiæ, and liver consumption. In India, the whole body (the head excepted) is immersed; but in this country pediluvia are usually employed, or the body is merely sponged with it.

ADMINISTRATION.—When taken internally, the dose is ten or fifteen drops, properly diluted, and carefully increased.

ANTIDOTE.—Poisoning by this acid is to be treated in the same way as that by sulphuric acid.

BALNEUM NITRO-HYDROCHLORICUM; *The Nitro-Muriatic Bath.*[3]—This is prepared in narrow wooden tubs, by adding the acid to tepid water, until the latter becomes as sour to the taste as vinegar. Ainslie[4] says one ounce of acid is enough for a gallon of water. The patient should remain in the bath from 10 to 30 or 40 minutes. It excites tingling and prickling of the skin, and is said to affect the gums and salivary glands, causing plentiful ptyalism: indeed, we are told that, without the latter effect, every trial is to be regarded as inconclusive. In the passage of biliary calculi this bath is said to have proved remarkably effective.—Dr. Scott's *nitrous acid bath* was prepared by acidulating water with fuming nitric acid (Ainslie).

29. AMMONIA.—AMMONIA.

Formula NH^3 or HAd. *Equivalent Wt.* 17. *Equivalent Vol. of the Gas* 2 or

HISTORY.—It is probable that Pliny was acquainted with the smell of ammonia, and that the "vehement odour" which he says[5] arose from mixing lime with nitrum was produced by the action of lime on sal ammoniac. Dr. Black, in 1756, first pointed out the distinction between ammonia and its carbonate; and Dr. Priestley[1] first procured ammonia in a gaseous form. It is sometimes termed *volatile alkali*, and occasionally *azoturetted hydrogen* or *terhydruret of nitrogen*. Dr. Kane regards it as *hydramid* or *amidide of hydrogen*.

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[1] Poggendorff's *Annalen*, Bd. lxiv. S. 429, 1845.

[2] *British and Foreign Medical Review*, vol. iv. p. 254.

[3] See Coyne's *Observations on the Aid obtained in various Diseases, particularly those incidental to Tropical Climates, by the External Application of the Nitro-muriatic Acid in a Bath*, Lond. 1822.

[4] *Materia Indica*, vol. ii. p. 340.

[5] *Historia Naturalis*, lib. xxxi. cap. 46, ed. Valp.

NATURAL HISTORY.—Ammonia, free or combined, exists in both kingdoms of nature.

a. IN THE INORGANISED KINGDOM.—Hydrochlorate and sulphate of ammonia are met with native usually in the neighbourhood of volcanoes. Aluminous sulphate of ammonia (or ammonia-alum) occurs in Bohemia. Dr. Marcet detected the hydrochlorate in sea water. This salt has also been recognised in mineral waters.[2] Ammonia exists in many of the native oxides of iron, and in most kinds of clay. Carbonate of ammonia is a constituent of the atmosphere, and is, therefore, found in rain water.

β. IN THE ORGANISED KINGDOM.—Ammonia is found in vegetables in small quantities only. In the free state, it is said to exist in several plants, as *Chenopodium vulvaria*, *Sorbus aucuparia*,[3] in the juice of the leaves of *Isatis tinctoria*, in the bark of *Zanthoxylum Clava Herculis*, and in *Fucus vesiculosus*. Combined with carbonic acid, it is found in *Justicia purpurea*; with nitric acid, in the extract of hyoscyamus, distilled water of the lettuce, &c. In combination with different substances, it is found in the root of *Helleborus niger*, and of *Nymphæa*; in the leaves of *Aconitum Napellus*; in the barks of *Cusparia febrifuga* and *Simaruba*; and in the fruit of *Areca Catechu*.[4] Lastly, it is developed during the decomposition (spontaneous or artificial) of most vegetable substances—as gluten.

Ammonia is one of the bases found in the urine of man, where it exists in combination with phosphoric, hydrochloric, and uric acids. United to the last-mentioned acid, it exists in the excrement of the boa constrictor, and of some birds. The hydrochlorate is found in the dung of the camel. Ammonia is a product of the putrefaction of animal matters.

1. Gaseous Ammonia.

SYNONYMES.—This is commonly called *ammoniacal gas* (*gas ammoniacale*). Dr. Priestley denominated it *alkaline air*. It has also been termed *urinous air*.

PREPARATION.—Ammoniacal gas is obtained by heating a mixture of one part powdered sal ammoniac and two parts dry quicklime in a glass retort, and collecting the gas over mercury. In the absence of a mercurial apparatus, the gas may be generated in a Florence flask, to the mouth of which a straight glass tube is connected by means of a cork. The bottles which are to be filled with gas are to be inverted over the tube. To arrest the passage of water, a fold of blotting paper may be placed in the neck of the retort or in the glass tube.

If we regard sal ammoniac as hydrochlorate of ammonia, the reactions which occur in this process are as follows: One equivalent of hydrochlorate of ammonia is decomposed by one equivalent of lime; and the results of the decomposition are one equivalent of ammonia, one equivalent of chloride of calcium, and one equivalent of water. $NH^3,HCl + CaO = NH^3 + HO + CaCl$.

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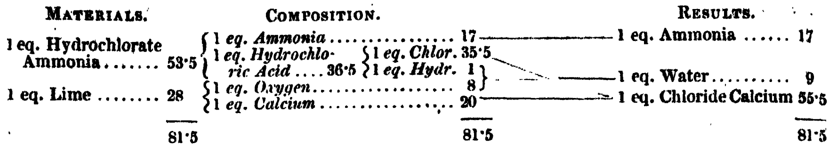
[1] *On Air*, vol. ii. p. 369, 1790.

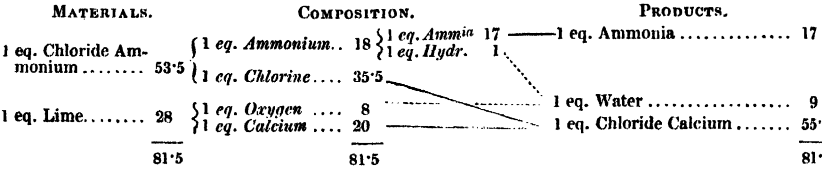
[2] Gairdner, *On Mineral Springs*, p. 15.

[3] *Dict. des Drogues*, t. i. p. 293.

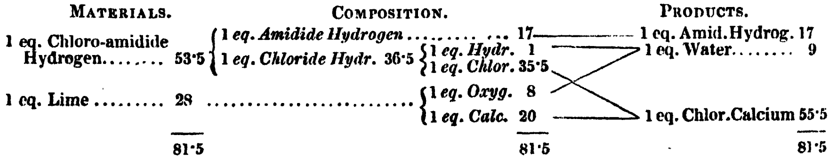
[4] De Candolle, *Physiol. Végét.* p. 339.


MATERIALS.
COMPOSITION.
RESULTS.
1 eq. Hydrochlorate Ammonia .... 53·5
1 eq. Ammonia 17
1 eq. Hydrochloric Acid .... 36·5
1 eq. Chlor. 35·5
1 eq. Hydr. 1
1 eq. Lime 28
1 eq. Oxygen 8
1 eq. Calcium 20
1 eq. Ammonia 17
1 eq. Water 9
1 eq. Chloride Calcium 55·5
81·5
81·5
81·5

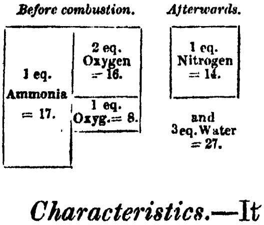
If, on the other hand, we consider sal ammoniac as a chloride of ammonium, the explanation is as follows: One equivalent of chloride of ammonium is decomposed by one equivalent of lime; and the products are one equivalent of ammonia, one of chloride of calcium, and one of water. $NH^4,Cl + CaO = NH^3 + HO + CaCl$.



But, according to Dr. Kane, ammonia is an amidide of hydrogen, and sal ammoniac is a chloro-amidide of hydrogen; and the changes are thus explained: One equivalent of the chloro-amidide of hydrogen is decomposed by one of lime, the products being one of the amidide of hydrogen, one of water, and one of chloride of calcium, $HAd,HCl + CaO = HAd + HO + CaCl$.



PROPERTIES.—Ammonia is a colourless invisible gas, having a strong well-known odour. It reddens turmeric paper, and changes the colo violet juice to green; but by exposure to the air, or by the applicatio both the turmeric paper and violet juice are restored to their origin The specific gravity of this gas is 0·59. By a pressure of 6·5 atm at a temperature of 50°, it is condensed into a colourless, transpare whose sp. gr. is 0·731. One volume of this liquid expanded into 10 of ammoniacal gas at 60° F., barom. 30·2 inches. At −103° F., t froze into a white translucent crystalline su



Ammoniacal gas is not a supporter of com but is slightly combustible in the atmosphere when mixed with air or oxygen, it forms an exp mixture. Every two volumes of it require one a half volumes of oxygen for their complete combustion. The results of the explosion are, a volume of nitrogen and some water.

Characteristics.—It is readily recognised by its peculiar odour, by its action on turmeric paper, by its restoring the blue colour of reddened litmus paper, and by its forming white fumes with hydrochloric acid

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[1] Faraday, *Phil. Trans.* 1845.

or chlorine. Dissolved in water, it communicates a deep blue colour to the salts of copper, throws down with the bichloride of platinum a yellow precipitate (*bichloride of platinum and ammonium,* $NH^4Cl,PtCl^2$); with bichloride of mercury a white precipitate (which, according to Kane, is a *chloro-amidide of mercury,* $HgCl,HgAd$); with protonitrate of mercury a black precipitate (*subnitrate of mercury and ammonium,* $NH^4O,3Hg^2O,NO^5$); and with a concentrated solution of tartaric acid a crystalline precipitate (*bitartrate of the oxide of ammonium,* $NH^4O,HO,\overline{T}$).

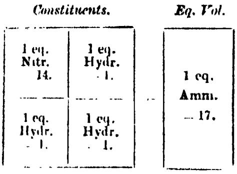
The salts of ammonia evolve ammoniacal gas when heated with hydrate of lime or potash.

Conia agrees with ammonia in evolving a vapour which reddens turmeric paper, and forms white fumes (hydrochlorate of conia) with hydrochloric acid gas.

COMPOSITION.—Ammonia is composed of hydrogen and nitrogen in the following proportions:—

	Atoms.	*Eq. Wt.*	*Per Ct.*	*A. Berthollet.*
Nitrogen	1	14	82·35	81·13
Hydrogen	3	3	17·65	18·87
Ammonia	1	17	100·00	100·00

	Vol.	*Sp. Gr.*
Nitrogen gas	1	0·971
Hydrogen gas	3	0·208
Ammoniacal gas	2	0·590



The annexed diagram illustrates the volumes of the constituents of the gas, and their degree of condensation when in combination to form ammoniacal gas.

THEORIES OF AMMONIA.—Three theories exist with regard to the nature of ammonia and the ammoniacal salts.

1. *Old* or *Ammonia Theory.*—Ammonia, NH^3, is an alkali which combines with the hydracids to form ammoniacal hydrsalts, and with both water and the oxyacids to form the ammoniacal oxysalts. Sal ammoniac, or hydrochlorate of ammonia, NH^3,HCl, is an example of a hydrsalt; sulphate of ammonia, NH^3,HO,SO^3, of an oxysalt.

2. Berzelius's *Ammonium Theory.*—Ammonium, NH^4, is an hypothetical compound metal. Its oxide, NH^4O, is equal to an equivalent of ammonia, NH^3, and an equivalent of water, HO. Ammonium combines with the radical of the hydracids to form the ammoniacal hydrsalts, and with oxygen and an oxyacid to form the ammoniacal oxysalts. Sal ammoniac, or chloride of ammonium, NH^4,Cl, is an example of a hydrsalt; sulphate of the oxide of ammonium, NH^4O, SO^3, of an oxysalt.

3. Kane's *Amide Theory.*—Amide, or amidogen, $Ad = NH^2$, is an hypothetical substance. It combines with hydrogen to form the amidide of hydrogen or ammonia, $HAd = H,NH^2$, and with two atoms of hydrogen to form the subamidide of hydrogen or ammonium, $H^2Ad = H^2,NH^2$. Berzelius's oxide of ammonium, NH^4O, is a compound of the amidide of hydrogen and water, HAd,HO. The amidide of hydrogen (ammonia) combines with the hydracids to form the hydrsalts: thus with chloride of hydrogen (hydrochloric acid) to form sal ammoniac. $HAd + HCl = HAd,HCl$. It combines with the dry oxygen acids, but does not then form the proper ammoniacal salts: thus with sulphuric acid, $HAd + SO^3 = HAdSO^3$. "It combines with a great number of saline bodies, and then resembles, in its functions, their water of crystallization. Its most remarkable property, however, is, that in acting on metallic compounds and on certain organic acids, it abandons an atom of hydrogen, and the remaining NH^2 combines with the metal or with the radical of the acid. Thus with HgCl and NH^3 there result $HgNH^2$ and HCl; with $PtCl^2$ and $2NH^3$ there are formed $Pt + 2NH^2$ and 2HCl; from $HgNO^6$ and NH^3 are produced $HgNH^2$ and HNO^6. Of organic bodies, oxalate of ammonia gives, when heated, $C^2O^2 + NH^2$, and benzoate of ammonia produces similarly $C^{14}H^5O^2 + NH^2$."[1]

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[1] Kane, *Elements of Chemistry,* p. 827; also, *Trans. of the Royal Irish Academy,* vol. xix. part i.

PHYSIOLOGICAL EFFECTS. α. *On Vegetables.*—Ammoniacal gas is destructive to plants, and changes their green colour to brown.[1]

β. *On Animals.*—If an animal be immersed in this gas, spasm of the glottis is immediately brought on, and death results from asphyxia (see *ante*, p. 113). Nysten[2] injected some of this gas into the veins of a dog: the animal cried out, respiration became difficult, and death soon took place. Neither gas nor visible lesion was observed in the heart, the two ventricles of which contained liquid blood. In another experiment he threw ammoniacal gas into the pleura of a dog: cries, evacuation of urine, and vomiting, immediately followed; soon afterwards convulsions came on, and continued for several hours: ultimately they ceased, and recovery took place.

In almost all cases of poisoning in animals, by ammonia or its carbonate, convulsions are observed, apparently shewing that these substances act on the spinal marrow.

γ. *On Man.*—Ammonia is a powerful local irritant. This is proved by its pungent odour and its acrid and hot taste; by its irritating the eyes; and, when applied for a sufficient length of time to the skin, by causing vesication. If an attempt be made to inhale it in the pure form, spasm of the glottis comes on: when diluted with atmospheric air, it irritates the bronchial tubes and larynx, and, unless the quantity be very small, brings on inflammation of the lining membrane. Its chemical action is analogous to that of the alkalies in general (see *ante*, pp. 94 and 176-8). Its powerful action on the nervous system is best seen in cases of syncope (see *ante*, pp. 224 and 225; also *aqua ammoniæ*).

USES.—Ammoniacal gas is rarely employed in medicine. M. Bourguet de Béziers used it with success in the case of a child affected with croup, to provoke the expulsion of the false membrane.

Mr. Smee[3] has proposed the inhalation of the vapour of a properly diluted liquor ammoniæ as a topical expectorant, to promote the secretion of a watery fluid from the mouth, fauces, trachea, and bronchi (see *ante*, p. 236). The apparatus he employs is similar to that used for the inhalation of chlorine (see *ante*, p. 372, figs. 66 and 67), except that the straight tube does not dip into the ammoniacal solution. He recommends this inhalation in what is called dryness of the throat from a deficiency in secretion, in chronic hoarseness, in chronic asthma, and to neutralize the poisonous effects of the vapour of bromine and hydrocyanic acid.

ANTIDOTE.—In case of the accidental inhalation of strong ammoniacal vapour, the patient should immediately inspire the vapour of acetic or hydrochloric acid. If bronchial inflammation supervene, of course it is to be treated in the usual way.

2. Aqua Ammoniæ.—Water of Ammonia.

SYNONYMES.—This solution is the *liquor ammoniæ* of the Pharmacopœia and shops, and which is sometimes called *aqua ammoniæ puræ* or *aqua ammoniæ causticæ*. It was formerly termed *spiritus salis ammoniaci*

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[1] De Candolle, *Physiol. Vég.* p. 1344.
[2] *Recherches*, p. 140.
[3] *Lond. Med. Gaz.* April 7, 1843.

causticus cum calce viva paratus, or simply the *spirit of sal ammoniac* or *caustic spirit of sal ammoniac*.

PREPARATION.—It is prepared by the action of lime on either sulphate or hydrochlorate of ammonia. On the large scale, the apparatus employed is an iron cylinder, connected with the ordinary worm refrigerator, and this with a row of double-necked stoneware bottles containing water, analogous to those described under the head of nitric acid.

All the British Colleges give formulæ for the preparation of *liquor ammoniæ*, sp. gr. 0·960. The following are the directions of the *London College*:—

"Take of Hydrochlorate of Ammonia ten ounces, Lime eight ounces, Water two pints: Put the Lime, slacked with water, into a retort, then add the Hydrochlorate of Ammonia, broken into small pieces, and the rest of the water. Let fifteen fluid-ounces of solution of ammonia distil."

The *Edinburgh College* gives the following directions for preparing *ammoniæ aqua*, sp. gr. 0·960, and *ammoniæ aqua fortior*, sp. gr. 0·880.

"Take of Muriate of Ammonia, thirteen ounces; Quicklime, thirteen ounces; Water, seven fluid-ounces and a half; Distilled Water, twelve fluid-ounces. Slake the Lime with the Water, cover it up till it cool, triturate it well and quickly with the Muriate of Ammonia previously in fine powder, and put the mixture into a glass retort, to which is attached a receiver with a safety-tube. Connect with the receiver a bottle also provided with a safety-tube, and containing four ounces of the distilled water, but capable of holding twice as much. Connect this bottle with another loosely corked, and containing the remaining eight ounces of distilled water. The communicating tubes must descend to the bottom of the bottles at the further end from the retort; and the receiver and bottles must be kept cool by snow, ice, or a running stream of cold water. Apply to the retort a gradually-increasing heat till gas ceases to be evolved; remove the retort, cork up the aperture in the receiver where it was connected with the retort, and apply to the receiver a gentle and gradually-increasing heat, to drive over as much of the gas in the liquid contained in it, but as little of the water, as possible. Should the liquid in the last bottle not have the density of ·960, reduce it with some of the stronger Aqua Ammoniæ in the first bottle, or raise it with distilled water, so as to form Aqua Ammoniæ of the prescribed density."

The *Dublin College* employs three parts of Muriate of Ammonia, two of fresh burned Quicklime, and ten of Water: The lime is to be slacked with one part of hot water, and then introduced into the retort, and the salt dissolved in the remaining hot water added, and five parts distilled by a medium [between 100° and 200°] heat into a refrigerated receiver.

The theory of the process is the same as that for ammoniacal gas. An excess of lime is used to facilitate the extrication of the ammonia. The water put into the receiver is to absorb the gas.

PROPERTIES.—Solution of ammonia is a colourless liquid, having a very pungent odour and a caustic alkaline taste. Its action on turmeric paper and violet juice is like that of ammoniacal gas, before described. It is lighter than water, but its sp. gr. varies with its strength. The quantity of ammoniacal gas which water can dissolve, varies with the pressure of the atmosphere and the temperature of the water.

Davy[1] ascertained that at the temperature of 50°, under a pressure equal to 29·8 inches, water absorbs about 670 times its volume of gas, and becomes of sp. gr. 0·875. He drew up the following table, shewing the quantity of ammonia in solutions of different specific gravities:—

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[3] *Elements of Chemical Philosophy*, p. 268.

100 parts of Sp. Gr.	Of Ammonia.	100 parts of Sp. Gr.	Of Ammonia.
0·8750 .... contain	32·50	0·9435 .... contain	14·53
0·8875	29·25	0·9476	13·46
0·9000	26·00	0·9513	12·40
0·9054	25·37	0·9545	11·56
0·9166	22·07	0·9573	10·82
0·9255	19·54	0·9597	10·17
0·9326	17·52	0·9619	9·60
0·9385	15·88	0·9692	9·50

It appears from the observations of Davy and Dalton that the specific gravity of mixtures of liquid ammonia and water is exactly the mean of that of two of the ingredients.

Characteristics.—See *Ammoniacal Gas,* p. 420.

Composition.—Solution of ammonia consists of ammonia and water. The proportions vary with the sp. gr. of the liquids. Two solutions are officinal in this country, *liquor ammoniæ* and *liquor ammoniæ fortior.*

1. *Liquor Ammoniæ,* Ph. L. E. D.; *Solution of Ammonia.*—The London and Edinburgh Colleges fix the sp. gr. of this solution at 0·960. A cubic inch of it consequently weighs 242·36 grains, and contains 132 cubic inches of ammoniacal gas. The Dublin College (1826) fixes the sp. gr. at 0·950. The following are about the strengths of these solutions, calculating from Davy's table:—

	Lond. and Edinb. Ph. (sp. gr. 0.960)	*Dub. Ph.* (sp. gr. 0·950)
Ammoniacal gas	10	12·75
Water	90	87·25
Liquor Ammoniæ	100	100·00

2. *Liquor Ammoniæ Fortior,* Ph. Lond.; *Aqua Ammoniæ Fortior,* Ph. Ed.; *Stronger Solution of Ammonia.*—A strong solution of ammonia, under the above name, is kept in the shops for employment in smelling bottles and for the preparation of irritating liniments or embrocations (see *Linimentum ammoniæ compositum*). The sp. gr. of the solution ordered by the Edinburgh College is 0·880, which is the strength of the liquid as prepared by the manufacturer. The London College fixes the sp. gr. at 0·882. In a warm atmosphere, and especially when the bottle is frequently opened, or when the liquid is poured from one vessel to another, the gas escapes rapidly from the liquid, whose sp. gr. is in consequence usually lower than that fixed by either of the Colleges. Dr. Christison says the sp. gr. of the commercial solution commonly ranges between 0·886 and 0·910. When mixed with water, the sp. gr. of the mixture is that of the mean: hence, if four volumes of liquor ammoniæ fortior, sp. gr. 0·880, be mixed with eight and a quarter volumes of distilled water, the sp. gr. of the mixture will be about 0·960: for (0·880 × 4) + (1·000 × 8·25) ÷ 12·25 = 0·9608. The weight of a cubic inch of liquor ammoniæ fortior, sp. gr. 0·880, [illegible] about 222·16 grains; that of sp. gr. 0·882 is 222·66 grains: the latter holds dissolved nearly 400 cubic inches of ammoniacal gas.

The following are about the strengths of these solutions, calculating from Davy's table:—

	Edinb. Ph. (sp. gr. 0·880).	*Lond. Ph.* (sp. gr. 0·882).
Ammoniacal gas	31·2	30·5
Water	68·8	69·5
Liquor Ammoniæ fortior	100·0	100·0

PURITY.—A pure solution of ammonia has the following characters:—

> "By heat it totally evaporates in evanescent alkaline vapours as shown by turmeric. It gives no precipitate with lime-water. When saturated with nitric acid, neither sesquicarbonate of ammonia nor nitrate of silver throws down any thing."—Ph. L.
>
> The sp. gr. of *liquor ammoniæ*, Ph. L. E. should be 0·960; of *liquor ammoniæ fortior*, Ph. E. should be 0·880; of that of the Ph. L. 0·882.

Liquor ammoniæ frequently contains traces of carbonate of ammonia, which may be detected by lime-water or by a solution of the chloride of calcium, either of which occasions a white precipitate (*carbonate of lime*) if carbonic acid be present. When a portion of the liquid has been neutralized by pure carbonic acid, it ought not to cause a precipitate by the addition of nitrate of silver, of oxalic acid, or of sesquicarbonate of ammonia: for the first would indicate the presence of hydrochloric acid or chlorine; the second of lime; the third of lime or other earthy matter. If pure, it does not effervesce with dilute acids.

Dr. Maclagan[1] found some of the volatile ingredients of the liquor of gas works in liquor ammoniæ. When an excess of nitric or sulphuric acid was added to the solution of ammonia, a red colouration, passing into purple, took place. When the ammonia was supersaturated with hydrochloric acid, and a clean shaving of fir wood inserted in the fluid, it speedily became dyed of a rich purple, characteristic of pyrrol. Naphthaline was discovered by its odour and its crystalline-looking particles when a portion of the ammonia was supersaturated with sulphuric acid and submitted to distillation: the naphthaline was volatilized. The residue of the distillation, being mixed with a small quantity of caustic potash, evolved the odour of picoline. It is probable, therefore, that this liquor ammoniæ had been obtained by direct distillation from the ammoniacal liquor of gas works, and not from the purified sulphate or muriate of ammonia.

PHYSIOLOGICAL EFFECTS. α. *On Vegetables.*—The effects of ammonia on plants have been before noticed.

β. *On Animals.*—Orfila injected sixty grains of liquor ammoniæ into the jugular vein of a strong dog: tetanic stiffness immediately came on, the urine passed involuntarily, and the animal became agitated by convulsions: death took place in ten minutes. The body was immediately opened, when the contractile power of the muscles was found extinct. In another experiment, thirty-six grains of concentrated solution of ammonia were introduced into the stomach, and the œsophagus tied: in five minutes the animal appeared insensible, but in a few moments after was able to walk when placed on his feet; the inspirations were deep, and his posterior extremities trembled. In twenty hours he was insensible, and in twenty-three hours he died. On dissection, the mucous membrane of the stomach was found red in some places. These experiments show the effects of large doses of this solution on the nervous system. The first experiment agrees in its results (that is, in causing tetanic convulsions) with that made by Nysten, and which has been before mentioned, of throwing ammoniacal gas into the cavity of the pleura. From the convulsions it may be inferred that in these instances the spinal marrow was specifically affected.

γ. *On Man.* αα. *Local effects.*—In the concentrated form the local action of liquor ammoniæ is exceedingly energetic. Applied to the skin, it causes pain, redness, vesication, and destruction of the part; thus acting, first as a rubefacient, then as a vesicant, and lastly as a caustic or corrosive. Its emanations are also irritant: when they come in contact with the conjunctival membrane, a flow of tears is the result; when inhaled, their powerful action on the air-passages is well known. Persons in syncope are observed to be almost immediately raised from a death-like state merely by inhaling the vapour of this solution. In cases of insensibility it must be employed with great caution; for, if used injudiciously, serious, or even fatal consequences may result. Nysten[1] tells us that a physician, for some years subject to epilepsy, was found by his servant in a fit. In order to rouse his master, the latter applied a handkerchief, moistened with this solution, to his nose so assiduously, that he brought on bronchitis, of which the patient died on the third day. In the *Edinburgh Medical and Surgical Journal* there is the report of the case of a lad whose death was produced, or at least hastened, by an attendant applying, "with such unwearied but destructive benevolence," ammonia to the nose, that suffocation had almost resulted. Dyspnœa, with severe pain in the throat, immediately succeeded, and death took place forty-eight hours afterwards. A French physician also suffered ulceration of the mouth and violent pulmonary catarrh in consequence of the excessive use of ammonia, given as an antidote for hydrocyanic acid. More recently another case of poisoning by the vapour of ammonia has been published.[2] It arose from the accidental bursting of a carboy of liquor ammoniæ. The mucous membrane of the nose and lips was destroyed. The tongue was deprived of its epithelium, and a large quantity of sanguineous froth escaped from the mouth. The respiration was so difficult, that suffocation was feared. The pulse was feeble, irregular, and frequent. There were no convulsions. Bronchitis supervened, but the patient recovered.

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[1] *Monthly Journal of Medical Science*, June 1846.

When the solution of ammonia is swallowed in large doses, it acts as a powerfully corrosive poison; but modern well-marked cases of poisoning by it in the human subject are wanting. However, it is very evident that violent inflammation of all that part of the alimentary canal with which the poison may be in contact, would be the result, and if much were taken, decomposition of the part might be expected. When swallowed in a very dilute form, and in small quantity, the local phenomena are not very marked, and the effect of the substance is then seen in the affection of the general system.

The chemical action of ammonia on the tissues is analogous that of the other alkalies (see *ante*, p. 94).

ββ. Remote effects.—The remote effects may be investigated under two heads, according as they are produced by small or large doses. *In small or therapeutic doses*, such as we are accustomed to employ in the treatment of diseases, ammonia acts as a diffusible stimulant, excitant, or calefacient (see *ante*, p. 217). It produces a sensation of warmth in the mouth, throat, and epigastrium, frequently attended with eructations. A temporary excitement of the vascular system succeeds, but this quickly subsides. The heat of the skin is sometimes increased, and there is a tendency to sweating, which if promoted by the use of warm diluents and clothing, frequently terminates in copious perspiration. But the skin is not the only secreting organ stimulated to increased exertion; we observe the kidneys produce more urine, and frequently the quantity of bronchial mucus is increased. The nervous system is also affected, and the activity of its functions heightened. Wibmer[1] made several experiments on himself, and found that ammonia affects the head, sometimes causing oppression or a sense of fulness, but no pain. The increased capability of muscular exertion, and the greater facility with which all the functions are executed, are further indications of the action of ammonia on the nervous system.

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[1] Christison, *Treatise on Poisons.*

[2] *Journ. de Chim. Méd.* t. vi. p. 499, 2nde sér.

There is, however, something remarkably different between the stimulant effects of ammonia and those of alcohol or opium. The first acts on the vascular system chiefly; the two latter on the cerebral system. The first has been termed by Dr. G. B. Wood[2] an arterial stimulant; the latter cerebral stimulants. The first may be employed with great benefit in many inflammatory and febrile cases, in which the latter proves highly prejudicial. According to Dr. Billing,[3] ammonia is *not*, like wine and tincture of opium, a diffusible stimulant. "In the first place," he observes, "ammonia is used empirically, by the most able of the profession, in cases where they know from experience that they must not employ wine or tincture of opium. This alone shows that it is not really a diffusible stimulant—it is a local one; and as such, through the medium of the solar plexus, excites the heart momentarily, though not injuriously. Again, so far from being a diffusible stimulus, it immediately unites with animal acids, and then circulates, or is *diffused*, not as a stimulant, but as a *sedative* saline; so as to perform the double operation of a temporary local stimulant to the stomach and heart, and a sedative to inflamed capillaries elsewhere, although the latter indication be not contemplated in its administration."

The effects of large or poisonous doses on the human subject have not been described; but that the nervous system is affected, seems probable from a case mentioned by Plenck,[4] which terminated fatally in four minutes, though the symptoms are not related (see *ammoniæ sesquicarbonas*).

If we compare the effects of ammonia with those of other stimulants, as camphor, wine, and opium, we observe, in the first place, that the influence of ammonia is principally manifested in the ganglionic and true spinal systems,—while the other stimulants, above mentioned, affect the cerebral system. Thus the effects of ammonia are usually exhibited on the circulation, respiration, secretion, and spasmodic actions; but camphor, wine, and opium, though they also affect these functions, yet they principally affect the intellectual functions. Secondly, the effects of ammonia are more transient than those of the other agents just referred to. Thirdly, the vascular excitement caused by wine and opium is attended with diminished mucous secretion, and is allied more to an ordinary febrile attack.

USES.—Ammonia is adapted for speedily rousing the action of the vascular and respiratory systems, and for the prompt alleviation of spasm. It is more especially fitted for fulfilling these indications when our object is at the same time to promote the action of the skin. It is calculated for states of debility with torpor or inactivity. It is also used as an antacid and local irritant.

1. *In dyspeptic complaints, accompanied with preternatural acidity of stomach and flatulence*, but without inflammation, a properly diluted solution of ammonia may be employed with a two-fold object — that of neutralizing the free acid, and of stimulating the stomach. It must be

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[1] *Die Wirkung*, &c. Bd. i. S. 123.

[2] *Syllabus of a Course of Lectures on Materia Medica and Pharmacy*, Philadelphia, 1847.

[3] *First Principles of Medicine*, p. 158, 4th edit. Lond. 1841.

[4] *Toxicologia*, p. 226, ed. 2nda, Viennæ, 1801.

remembered that the healthy secretions of the stomach are of an acid nature, and that the continued use of ammonia, or any other alkali, must ultimately be attended with injurious results, more especially to the digestive functions. While, therefore, the occasional employment of alkalies may be serviceable, their constant or long-continued use must ultimately prove deleterious.

Ammonia may, under some circumstances, be employed to neutralize acids introduced into the stomach from without, as in poisoning by the mineral acids; though chalk and magnesia would be more appropriate, being less irritant. It is a valuable antidote in poisoning by hydrocyanic acid. Its beneficial operation has been ascribed to the union of the alkali with the acid, whereby hydrocyanate of ammonia is formed; but since it has been found that this salt is highly poisonous, it is evident that this statement cannot be correct. Some have ascribed the activity of the hydrocyanate to its decomposition by the free acids of the stomach, and the consequent evolution of free hydrocyanic acid; but this explanation is not satisfactory. I believe the efficiency of ammonia as an antidote to poisoning by hydrocyanic acid, arises from its exerting an influence of an opposite nature to that of the poison. In poisoning by the oil of bitter almonds, or other agents supposed to contain this acid, ammonia is equally serviceable. The antidote should be given by the stomach, if the patient can swallow, and the vapour should be cautiously inhaled.

2. *To produce local irritation, rubefaction, vesication, or destruction of the part.*—As a *local agent*, ammonia has been employed in a variety of diseases—sometimes as a rubefacient or irritant, sometimes as a vesicant, and occasionally as a caustic. Thus it is employed as a rubefacient in rheumatic and neuralgic pains, and as a counter-irritant to relieve internal inflammations. As a local irritant, a weak solution has been injected into the vagina and uterus, to excite the catamenial discharge; but there are some objections to its use. Thus, it is a most unpleasant kind of remedy, especially to young females; moreover, the stoppage of this discharge is in many cases dependent on constitutional or remote causes, and, therefore, a topical remedy is not likely to be beneficial. Lavagna employed ten or fifteen drops of the solution, diluted with milk. The following is Nisato's formula:—

℞ Ammon. liquid. gtt. xl.; Decoct. Hordei, unc. viii.; Mucilag. Arab. unc. dimid. Misce, et fiant quatuor intra diem injectiones.

Sometimes ammonia is employed as a vesicatory; and it has two advantages over cantharides—a more speedy operation, and non-affection of the urinary organs: It may be employed either in the form of ointment or solution. As a caustic, the strong solution of ammonia may be sometimes used with advantage in the bites of rabid animals.

3. *The vapour of the solution of ammonia may be inhaled* when we wish to make a powerful impression on the nervous system—as in syncope, or to prevent an attack of epilepsy. To guard against or relieve fainting, ammoniacal inhalations are very powerful and useful: their instantaneous operation is frequently astonishing. Pinel says, he once saw an attack of epilepsy prevented by this means. The patient (a watchmaker) had intimations of the approaching paroxysm from certain feelings; but he found, by inhaling the vapour of ammonia, it was frequently prevented. In the case of a confirmed epilepsy, which I was in the habit of watching for some years, I think I have

also seen analogous beneficial effects. I speak doubtfully, because it is so difficult to determine, in most cases, the actual approach of the fit. It is deserving of especial notice, that ammonia is useful in three conditions of the system, which, though produced by very different causes, present analogous symptoms; viz. idiopathic epilepsy—the insensibility and convulsions (? epilepsy) produced by loss of blood—and the insensibility and convulsions (? epilepsy) which poisonous doses of hydrocyanic acid give rise to. (See *ante*, p. 213; also *ammoniæ sesquicarbonas*).

In asphyxia, ammoniacal inhalations have been strongly recommended by Sage, who says that he produced the apparent death of rabbits by immersion in water, and recovered them subsequently by the use of ammonia; and a case is mentioned of a man who had been submerged in the Seine for twenty minutes, and when taken out of the water, appeared lifeless, yet by the use of ammonia recovered; and a M. Routier, a surgeon of Amiens, is said to have restored a patient in the same way. That it may sometimes be of service I can readily believe, but it must be employed with great caution.

The employment of the vapour of ammonia, by Mr. Smee, as a topical expectorant, has been already noticed (see *ante*, p. 422).

4. *Ammonia is given internally as a stimulant and sudorific* with manifest advantage in several cases, of which the following are illustrations:—

α. In continued fevers which have existed for some time, and where all violent action has subsided, and the brain does not appear much disordered, it is occasionally of great service. Its diaphoretic action should be promoted by diluents and warm clothing. It has an advantage over opium—that, if it do no good, it is less likely to do harm.

β. In intermittent fevers it is sometimes of advantage, given, during the cold stage, to hasten its subsidence.

γ. In the exanthemata, when the eruption has receded from the skin, and the extremities are cold, it is sometimes of great benefit, on account of its stimulant and diaphoretic properties. But in some of these cases the recession arises from, or is connected with, an inflammatory condition of the bronchial membrane, for which the usual treatment is to be adopted.

δ. In some inflammatory diseases (especially pneumonia and rheumatism), where the violence of the vascular action has been reduced by proper evacuations, and where the habit of the patient is unfavourable to the loss of blood, ammonia has been serviceable. In combination with decoction of senega, I have found it valuable in old pulmonary affections. (See *Senega*.)

5. *In certain affections of the nervous system*, ammonia is frequently employed with the greatest benefit. Thus it has been used to relieve the cerebral disorder of intoxication. In poisoning by those cerebro-spinants commonly termed sedatives—such as foxglove, tobacco, and hydrocyanic acid, ammonia is a most valuable agent. This remedy has been supposed to possess a specific influence in relieving those disorders of the nervous system accompanied with spasmodic or convulsive symptoms: and hence it is classed among the remedies denominated *antispasmodic*. Velsen, of Cleves, has used it with advantage in delirium tremens. It was a remedy frequently tried in the malignant or Indian cholera, and occasionally procured relief, but it was not much relied on.

6. *Against the bites of poisonous animals*—as serpents and insects, ammonia is frequently employed with the best effects. There does not appear,

however, any ground for the assertion of Sage, that it is a specific: in fact, Fontana declares that it is sometimes hurtful in viper bites.[1]

ADMINISTRATION.—It is given in doses of from five to twenty or thirty drops, properly diluted.

ANTIDOTES.—The diluted acids—as vinegar, lemon or orange juice, &c. are antidotes for ammonia. To abate the inflammatory symptoms caused by the inhalation of its vapour, blood-letting has been found serviceable.

1. **LINIMENTUM AMMONIÆ**, L. E. D.; *Liniment of Ammonia; Volatile Liniment; Oil and Hartshorn.* (Solution of Ammonia, f℥j. [fʒij. *D.*]; Olive Oil, f℥ij. Mix and shake them well together).—This is an ammoniacal soap composed of the oleo-margarate of ammonia mixed with some glycerine.[2] It is employed as an external stimulant aud rubefacient, to relieve rheumatic and neuralgic pains, lumbago, sore throat, sprains, bruises, &c.

2. **LINIMENTUM AMMONIÆ COMPOSITUM**, E.; *Compound Liniment of Ammonia.* (Stronger Aqua Ammoniæ [sp. gr. 0·880], f℥v.; Tincture of Camphor, f℥ij.; Spirit of Rosemary, f℥j. Mix them well together. This liniment may be also made weaker for some purposes, with three fluidounces of Tincture of Camphor and two of Spirit of Rosemary).—These are obvious imitations of Dr. Granville's *counter-irritating* or *antidynous lotions.*[3] This liniment may be used so as to produce rubefaction, vesication, or cauterization. A piece of linen six or seven times folded, or a piece of thick and coarse flannel impregnated with this liniment, is to be applied to the part and covered with a thick towel, which is to be firmly pressed against the part. If rubefaction merely be desired, the application is continued for from one to six or eight minutes; but from ten to twelve minutes are necessary to excite vesication and cauterization. In painful and spasmodic affections, as neuralgia, cramp, &c.; in rheumatism, lumbago, and swollen and painful affections of the joints; in headache, sore throat, sprains, and many other cases, benefit may be obtained from a powerful and speedy counter-irritant like this, as stated by Dr. Granville.

3. **UNGUENTUM AMMONIÆ**; *Liparolé d'Ammoniaque; Pommade Ammoniacale de Gondret; Gondret's Ammoniacal Ointment.*—The formula for this, as given by Soubeiran,[4] is as follows:—Suet one part, Hog's Lard one part, and Strong Solution of Ammonia two parts. In Gondret's[5] work, however, the following formula is given:—Hog's Lard, ℥vij.; Oil of Sweet Almonds, ʒiss.; and Strong Liquid Ammonia, from ℥v. to ℥vj. Melt the lard, mix it with the oil, and pour them into a wide-mouthed bottle with a ground glass stopper; then add the ammonia, close the bottle, mix the contents together by shaking, and keep the mixture in a cool place.—This ointment, rubbed on the skin and covered by a compress, speedily produces vesi-

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[1] For some other uses of ammonia, see *Ammoniæ Sesquicarbonas.*

[2] See the articles *Soap* and *Olive Oil.*

[3] *Lancet,* Oct. 27, 1838; and *Brit. and For. Med. Rev.* vol. vii. p. 292. Also Dr. Granville's work, entitled *Counter-irritation, its Principles and Practice, illustrated by one hundred cases of the most painful and important diseases effectually cured by external applications,* Lond. 1838.

[4] *Nouveau Traité de Pharmacie,* t. ii. p. 302, 2nde éd. Paris, 1840.

[5] *Traité Théorique et Pratique de la Dérivation contre les Affections les plus communes en général, telle la Pléthore, l'Inflammation, l'Hémorrhagie,* &c. Paris, 1837: reviewed in the *British and Foreign Medical Review,* vol. vii. p. 56.

cation. Without the compress it causes rubefaction. It is a very useful rubefacient, vesicant, and counter-irritant.

4. **TINCTURA AMMONIÆ COMPOSITA**, L. *Spiritus Ammoniæ succinatus.* (Mastic, ʒij.; Rectified Spirit, f℥ix.; Oil of Lavender, ♏xiv.; Oil of Amber, ♏iv.; Stronger Solution of Ammonia, Oj. Macerate the mastic in the spirit, that it may be dissolved, and pour off the clear tincture; then add the other ingredients, and shake them all together.)—This liquid is milky, owing to the separation of the mastic from its spirituous solution by ammonia. This preparation is an imitation of the liquid commonly called *Eau de Luce*[1] (*Aqua Luciæ*), after its inventor, who by some is said to have been an apothecary at Lille. M. B. Jussieu[2] gave it to one of his pupils who had been bitten by a viper; and, as the patient recovered, the remedy acquired considerable celebrity as a counter-poison to the bites of venomous snakes. But Fontana[3] has shown, that ammonia (its active principle) does not possess any powers of this kind. The compound tincture of ammonia is a powerful antispasmodic stimulant, and is now principally employed as an antihysteric, in doses of from ten to thirty or forty minims. It has also been used as a stimulating embrocation. In angina pectoris it is also sometimes used as a stimulant and antispasmodic.

5. **SPIRITUS AMMONIÆ**, E. *Spirit of Ammonia.* (Rectified Spirit, Oij.; Fresh-burnt Lime, ℥xij.; Muriate of Ammonia, in very fine powder, ℥viij.; Water, f℥viss. Let the lime be slaked with the water in an iron or earthenware vessel, and cover the vessel till the powder be cold; mix the lime and muriate of ammonia quickly and thoroughly in a mortar, and transfer the mixture at once into a glass retort; adapt to the retort a tube which passes nearly to the bottom of a bottle containing the rectified spirit; heat the retort in a sand-bath gradually, so long as anything passes over, preserving the bottle cool. The bottle should be large enough to contain one-half more than the spirit used.)—In this process we obtain, by the mutual reaction of the sal ammoniac and lime (see *ante*, pp. 419 and 420), ammoniacal gas, which passes over, and is dissolved in the spirit contained in the receiver. This preparation, which is a solution of caustic ammonia, is a more energetic solvent of resins and volatile oils, and a more powerful physiological agent than its namesake, the *spiritus ammoniæ* of the London and Dublin Pharmacopœias, which is a solution of carbonate of ammonia. It is a stimulant antispasmodic. Doses ♏xxx. to fʒj.—The Edinburgh College directs it to be employed in the preparation of the *Spiritus Ammoniæ Aromaticus*, *Spiritus Ammoniæ fœtidus*, *Tinctura Castorei Ammoniata*, *Tinctura Guaiaci Ammoniata*, *Tinctura Opii Ammoniata*, and *Tinctura Valerianæ Ammoniata.*

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[1] See the history of this preparation in Beckmann's *Hist. of Inventions and Discoveries*, vol. iv. p. 595, Lond. 1814. Beckmann says that Dossie, in his *Elaboratory laid open* (Lond. 1758), first gave a proper account of this preparation.

[2] *Histoire de l'Académie Royale des Sciences*, Année 1747, p. 54.

[3] *Treatise on the Venom of the Viper*, vol. ii. Lond. 1787.

30. AMMONIÆ CARBONATES.—CARBONATES OF AMMONIA.

HISTORY.—Both solid and liquid compounds of ammonia and carbonic acid have been known for several centuries. The manufacture of solid carbonate of ammonia has been probably long known to the Hindoos. Ainslie[1] gives a Tamool formula for its preparation by the sublimation of a mixture of sal ammoniac and chalk, but its date is unknown. The Arabians perhaps derived their knowledge of carbonate of ammonia from the Hindoos. Geber[2] speaks of *sal urinæ* "made of the calcined feces of the urine distilled." Raymond Lully, in the 13th century, was acquainted with the impure solution of carbonate of ammonia obtained from putrid urine; and it is probable that the Arabians had known it long before. Basil Valentine[3] speaks of the *spiritus salis urinæ*.

The real distinction between ammonia and its carbonate was pointed out by Dr. Black in 1756. Sir H. Davy[4] ascertained the existence of many varieties of carbonate of ammonia "containing very different proportions of carbonic acid, alkali, and water." His brother, Dr. J. Davy,[5] ascertained the existence of three definite compounds, viz. a carbonate, sesquicarbonate, and bicarbonate—and further, a hydrated carbonate.

More recently Professor Heinrich Rose[6] has described no less than twelve combinations, as follows:—

			Formulæ. (The carbonic acid is assumed to be combined with ammonia.)		
Neutral or *Mono-carbonate*	1.	Neutral anhydrous carbonate	NH^3	CO^2	
	2.	Neutral hydrous carbonate	$2NH^3$	$2CO^2$	HO
$\frac{5}{4}$ *Carbonate*	3.	$\frac{5}{4}$ Carbonate with 4 equivalents of water	$4NH^3$	$5CO^2$	$4HO$
	4.	$\frac{5}{4}$ Carbonate with 5 equivalents of water	$4NH^3$	$5CO^2$	$5HO$
	5.	$\frac{5}{4}$ Carbonate with 12 equivalents of water	$4NH^3$	$5CO^2$	$12HO$
Sesquicarbonate ..	6.	Sesquicarbonate (commercial) with 2 equivalents of water	$2NH^3$	$3CO^2$	$2HO$
	7.	Sesquicarbonate with 5 equivalents of water	$2NH^3$	$3CO^2$	$5HO$
$\frac{7}{4}$ *Carbonate*	8.	$\frac{7}{4}$ Carbonate...	$4NH^3$	$7CO^2$	$12HO$
Bicarbonate	9.	Bicarbonate with 2 equivalents of water	NH^3	$2CO^2$	$2HO$
	10.	Bicarbonate with $2\frac{1}{2}$ equivalents of water	$2NH^3$	$4CO^2$	$5HO$
	11.	Bicarbonate with 3 equivalents of water	NH^3	$2CO^2$	$3HO$
$\frac{9}{4}$ *Carbonate*	12.	$\frac{9}{4}$ Carbonate	$4NH^3$	$9CO^2$	$10HO$

NATURAL HISTORY (see *Ammonia*, p. 419).—Carbonate of ammonia is formed during the putrefaction or destructive distillation of those organic substances which contain nitrogen. It is a constituent of rain water.

PROPERTIES.—All the combinations of ammonia and carbonic acid are solids which have an ammoniacal odour; but the greater the quantity of carbonic acid they contain, the weaker is their odour. It is not perceptible at first in the recently prepared combinations with excess of carbonic acid, and not till they have been preserved in a vessel for some time unexposed to the air. The anhydrous carbonate may be volatilized unchanged; but all the combinations with more carbonic acid than contained in the neutral salt do not volatilize undecomposed (Rose).

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[1] *Materia Indica*, vol. i. p. 367, 1826.

[2] *The Works of Geber*, p. 246, Lond. 1678.

[3] *Chymische Schriften*, Ander-Theile, S. 392, Hamb. 1677.

[4] *Researches, Chemical and Philosophical, chiefly concerning Nitrous Oxide*, 1800.

[5] *Edinburgh New Philosophical Journal* for April 1834.

[6] Poggendorff's *Annalen*, vol. xlvi. part 3; also Taylor's *Scientific Memoirs*, vol. ii. 1841.

Characteristics.—Volatilizable without residuum. When heated with water and a caustic alkali or earth, they evolve ammoniacal gas, the characters of which have been already stated (see *ante*, p. 420).

A solution of a carbonate of ammonia is distinguished from a solution of caustic ammonia by its effervescence with a dilute mineral acid, and by the white precipitates which it occasions with lime water, with chloride of barium, and with chloride of calcium.

The neutral or mono-carbonate of ammonia is distinguished from the other carbonates by the following circumstances: if the solution contain a neutral carbonate only, the whole of its carbonic acid is thrown down in combination with baryta by the addition of chloride of barium, and the liquor separated from the carbonate of baryta yields no further precipitate on the addition of pure liquid ammonia: but if the solution contain any super-carbonate of ammonia, a further precipitate takes place when pure liquid ammonia is subsequently added.

COMPOSITION.—Several of these combinations are perhaps double salts; especially the sesquicarbonate and $\frac{5}{4}$ carbonates, which are probably compounds of the anhydrous carbonate of ammonia, and either bicarbonate of the oxide of ammonium or bicarbonate of ammonia. If the $\frac{7}{4}$ carbonate and $\frac{9}{4}$ carbonate be also considered as double salts, of which the neutral anhydrous carbonate forms the one constituent, we are compelled to assume the existence of a quadricarbonate of the oxide of ammonium, or hydrous quadricarbonate of ammonia, a combination which has never yet been isolated. The $\frac{7}{4}$ carbonate will then consist of the anhydrous carbonate and the quadricarbonate; and the $\frac{9}{4}$ carbonate will be composed of the anhydrous carbonate, the bicarbonate, and the quadricarbonate.

The existence of an anhydrous carbonate of ammonia would appear to be a stumbling-block to Berzelius's ammonium theory. Rose, however, thinks that this theory is so plausible, and has justly been adopted by so many chemists, that the composition and properties of the anhydrous carbonate are insufficient to render the theory less possible. This carbonate, therefore, is regarded as a peculiar body, and has been sometimes termed *carbonate of hydramide* (HAd,CO^2). Dumas calls it *carbonamide* (Ad,CO,HO.)

EFFECTS.—The effects of the carbonates of ammonia are similar to, but milder than, those of pure or caustic ammonia (see *ante*, p. 425); and they are milder in proportion as the quantity of carbonic acid they contain is greater. The neutral or mono-carbonate, therefore, is more powerful than the sesquicarbonate, and this than the bicarbonate.

1. Ammoniæ Monocarbonas.—Neutral Carbonate of Ammonia.

Formula $2NH^3,2CO^2,HO$; or (NH^3,CO^2+NH^4,O,CO^2). *Equivalent Weight* 87.

HISTORY.—Rose (see *ante*, p. 432) describes two neutral carbonates of ammonia, the one anhydrous, and the other hydrous. The former, however, appears to be an amide (see *ante*, p. 433). The latter, therefore, alone requires notice here. Rose terms it the *neutral hydrous carbonate of ammonia.* It is the *ammoniæ carbonas* of the Dublin Pharmacopœia.

Preparation.—Hydrated neutral carbonate of ammonia is the first, and, therefore, the most volatile, of the solid products which appear in the distillation of the commercial hydrated sesquicarbonate of ammonia. If the latter be digested in a small quantity of water, we obtain a solution of a neutral carbonate of ammonia, mixed, however, with a little of the bicarbonate. When the hydrated sesquicarbonate is distilled with alcohol, carbonic acid is evolved, and the neutral carbonate passes into the receiver along with the vapour of alcohol.

The same neutral carbonate is obtained when a mixture of sal ammoniac and carbonate of either soda or potash is submitted to distillation with water; and on this principle several officinal liquid preparations (presently to be mentioned) of the neutral carbonate are directed to be prepared. At the commencement of the distillation ammoniacal gas only escapes.

The *Dublin College* orders equal parts of Muriate of Ammonia, pulverised and well dried, and dried Carbonate of Soda. Pass the mixture into an earthenware retort, and, with a heat gradually increased, sublime the carbonate of ammonia into a refrigerated receiver.

According to the old or ammonia theory, the following equation explains the changes which occur:—$2(NH^3,HCl)+2(NaO,CO^2)=2NH^3,2CO^2,HO+2(NaCl)+HO$. But on the ammonium theory the equation is as follows:—$2(NH^4,Cl)+2(NaO,CO^2)=(NH^3,CO^2+NH^4O,CO^2)+2(NaCl)+HO$.

Dr. Barker states, that "a product of greater whiteness and purity is obtained by carbonate of soda than by chalk as directed in the processes of the London and Edinburgh Colleges."[1] The fact is, its constitution is different.

Properties.—Hydrated neutral carbonate of ammonia is a crystalline salt, having an ammoniacal odour, but weaker than that of a solution of caustic ammonia. It is very volatile, and may be again sublimed without changing very essentially its composition. According to Dr. John Davy it is a deliquescent salt, but Rose did not find it to be so.

Characteristics.—See *ante*, p. 433. Its solution yields, on the addition of chloride of barium, a white precipitate (*carbonate of baryta*): and no further precipitate is obtained by the further addition of caustic ammonia to the mixture. This character distinguishes the neutral carbonate from the super-carbonates of ammonia (see *ante*, p. 433).

Composition.—The hydrated neutral carbonate of ammonia has, according to Rose, the following composition:—

	Atoms.	*Eq. Wt.*	*Per Ct.*	*Rose.*
Ammonia	2	34	39·080	39·27
Carbonic Acid	2	44	50·575	50·09
Water	1	9	10·345	10·64
Neutral Hydrated Carbonate of Ammonia	1	87	100·000	100·00

	Atoms.	*Eq.Wt.*	*PerCt.*
Carbonate of Ammonia	1	39	44·83
Carbonate of Oxide of Ammonium	1	48	55·17
	1	87	100·00

According to Rose, this salt is most probably a compound of the anhydrous carbonate of ammonia and carbonate of the oxide of ammonium.

Physiological Effects.—See *ante*, p. 433. It is less powerful than caustic ammonia, but more so than the sesquicarbonate and bicarbonate.

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[1] Barker, *Observations on the Dublin Pharmacopœia.*

USES.—In the solid state it is not employed in medicine. Several officinal liquids, however, owe their medicinal activity to it.—Carbonate of ammonia is directed by the Dublin College to be used in the manufacture of several preparations which are usually made with the ordinary sesquicarbonate of ammonia of commerce (see *Ammoniæ Sesquicarbonas*).

The solid neutral carbonate of ammonia is preferable to the sesquicarbonate for smelling bottles, as it does not lose its pungency by keeping, but as it evaporates it leaves the residue as good as ever. Whereas the sesquicarbonate by exposure gives out its neutral carbonate, and becomes the bicarbonate, which has but little odour.—SYLVIUS'S SAL VOLATILE OLEOSUM was the neutral carbonate flavoured with volatile oils. It was prepared by submitting to distillation a mixture of sal ammoniac and carbonate of potash. Boerhaave gives a process for making an extemporaneous *sal volatile oleosum,* which he says was in great vogue in England in hysterical disorders.—MOUNSEY'S ORIGINAL PRESTON SMELLING SALTS are an obvious imitation of the preceding.—The PRESTON SALTS sold in the shops as a substitute are prepared extemporaneously by adding a few drops of liquor ammoniæ fortior and some volatile oils to coarsely powdered sesquicarbonate of ammonia.

1. **SPIRITUS AMMONIÆ CARBONATIS**; *Spiritus Ammoniæ,* L. D.; *Spiritus Salis Ammoniaci dulcis; Spirit of Carbonate of Ammonia; Spirit of Ammonia.*—The London College orders of Hydrochlorate of Ammonia, ℥x.; Carbonate of Potash, ℥xvj.; Rectified Spirit, Water, of each Oiij. Mix, and let three pints distil.

In this process double decomposition takes place (see *ante,* p. 434), and the carbonate of ammonia which is produced distils over with the spirit, in which the greater part of it dissolves, the remainder being deposited in an imperfectly crystalline state.—The sp. gr. of this solution is 0·860.

The Dublin College directs [Sesqui-] Carbonate of Ammonia, coarsely powdered, ℥iijss. to be dissolved, with a medium heat, in Rectified Spirit, Oiij. [*wine measure*].—During the solution in the heated spirit, the sesqui-carbonate evolves carbonic acid gas (see *ante,* p. 434), and is reduced to the state of carbonate of ammonia, of which about thirty grains are taken up by each ounce measure of the spirit.

The spiritus ammoniæ of the Edinburgh Pharmacopœia is a solution of ammoniacal gas in spirit (see *ante,* p. 431). The medicinal effects of this preparation are analogous to, but milder than, those of liquor ammoniæ (see *ante,* p. 425) and the spiritus ammoniæ, Ph. E. It may be employed in hysteria, flatulent colic, and nervous debility. It is, however, but little used except in the preparation of the two following compounds. The dose of it is from fʒss. to fʒj. properly diluted with water. Saturated with camphor, it forms a highly stimulating liniment.

2. **SPIRITUS AMMONIÆ FŒTIDUS,** L.E.D.; *Spiritus volatilis fœtidus; Fetid Spirit of Ammonia.*—In this, as in the preceding preparation, a difference exists in the formulæ of the British Colleges. The London and Dublin Colleges use a solution of carbonate of ammonia, while the Edinburgh College employs a solution of caustic ammonia.

The formula of the *London College* is the same as that for Spiritus Ammoniæ, *L.*; except that five ounces of Assafœtida are put into the retort with the other ingredients. The sp. gr. of this is 0·861.

The *Dublin College* orders Assafœtida ℥iss. to be macerated for three days in Spirit of Ammonia, Oij. [*wine measure*], shaking occasionally; then pour off the clear liquor, and distil a pint and a half.

The *Edinburgh College* employs spirit of Ammonia (see *ante,* p. 431), f℥xss.; Assafœtida, ℥ss. Break the Assafœtida into small fragments; digest it in the spirit for twelve hours; and distil over ten fluid ounces and a half by means of a vapour-bath heat.

This preparation is a very unnecessary one. It is merely a solution of the volatile oil of assafœtida in spirit of ammonia; for which a mixture of tincture of assafœtida and spirit of ammonia may be conveniently and more efficaciously substituted. It is a colourless, pungent, and fetid liquor, which becomes brownish by age. It is employed in hysteria in doses of from half a drachm to a drachm in water.

3. SPIRITUS AMMONIÆ AROMATICUS, L. E. D.; *Spiritus Salis Volatilis Oleosus; Spirit of Sal Volatile.*—The preparation of the London and Dublin Pharmacopœias is a solution of the carbonate of ammonia; but that of the Edinburgh Pharmacopœia contains caustic ammonia.

The *London College* gives the following formula:—Hydrochlorate of Ammonia, ℥v.; Carbonate of Potash, ℥viij.; Cinnamon, bruised; Cloves, bruised; of each, ʒij.; Lemon Peel, ℥iv.; Rectified Spirit; Water, of each, Oiv. Mix them, and let six pints distil.

In this process double decomposition takes place, as already noticed, and the carbonate of ammonia distils over with the spirit and part of the water flavoured by the essential oils of the aromatics used. The sp. gr. of this preparation is 0·914.

The *Dublin College* orders Spirit of Ammonia, Oij. [*wine measure*]; Essential Oil of Lemons, ʒij.; Nutmegs, bruised, ℥ss.; Cinnamon Bark, bruised, ʒiij. Macerate in a close vessel for three days, shaking occasionally; then distil a pint and a half.

The *Edinburgh College* orders of Spirit of Ammonia (see *ante*, p. 431), f℥viij.; Volatile Oil of Lemon Peel, fʒj.; Volatile Oil of Rosemary, fʒiss. Dissolve the oils in the spirit by agitation.

This preparation, on account of its more agreeable taste and smell, is usually preferred to the spiritus ammoniæ carbonatis above noticed, than which it is somewhat weaker. It is frequently employed in languor, fainting, hysteria, flatulent colic, and nervous debility, in doses of from fʒss. to fʒij. properly diluted with water. It is employed by the London College in the preparation of *Tinctura Guaiaci Composita,* and *Tinctura Valerianæ Composita.*

2. Ammoniæ Sesquicarbonas.—Sesquicarbonate of Ammonia.

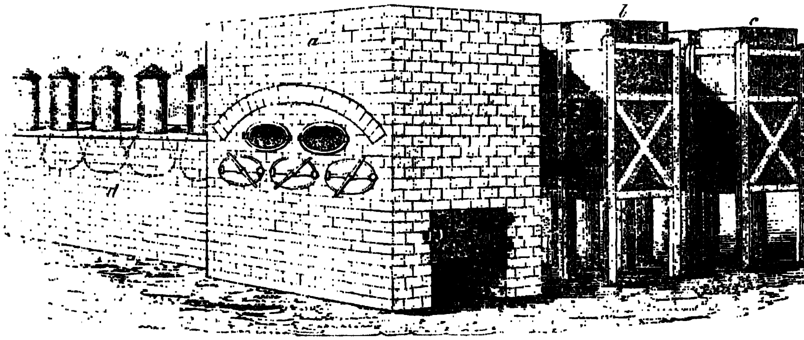
Formula $2NH^3,3CO^2,2HO$; or $(NH^3,CO^2 + NH^4O,2CO^2 + HO)$; or $(NH^4,O,CO^2 + NH^4,O,2CO^2)$. *Equivalent Weight* 118.

HISTORY.—This salt was probably known to Raymond Lully; but until late years it has been confounded with the other carbonates of ammonia. It is frequently denominated *subcarbonate of ammonia, carbonate of ammonia,* (*ammoniæ carbonas,* Ph. E. D.) *volatile or smelling salts,* or *baker's salt.* The last appellation has been given to it because of its use by bakers, as a substitute for yeast, in the manufacture of some of the finer kinds of bread.

It is probable that the terms *sal alkali volatile siccum* seu *urinosum, sal volatile salis ammoniaci,* and *sal volatile cornu cervi,* applied to this rather than to any other carbonate of ammonia.

PREPARATION.—Manufacturers prepare it by submitting to sublimation a mixture of sal ammoniac (or impure sulphate of ammonia) and chalk. In a manufactory which I inspected a few years since it was prepared as follows:—The retorts in which the sublimation was effected, were of cast iron, and similar in shape and size to those employed in the manufacture of coal gas. Each retort communicated posteriorly with a leaden receiver, with which was connected a second receiver of the same size and shape. The receivers had the form of square prisms placed endways, and were supported in a wooden frame-work. In some manufactories they are cylindrical, and have moveable tops and bottoms. The impure sesquicarbonate (*ammoniæ sesquicarbonas crudus*) thus obtained was contaminated with carbonaceous matter, which it deposited when dissolved in acids. It was refined in iron pots surmounted with leaden heads, and heated by the flue of the retort furnace. A little water was introduced into the pots to render the sesquicarbonate translucent. In another manufactory which I inspected, the pots were heated by a water-bath; a temperature of 150° F. being, I am informed, sufficient for this process. In this way *refined sesquicarbonate* (*ammoniæ sesquicarbonas rafinatus*) is obtained.

FIG. 72.



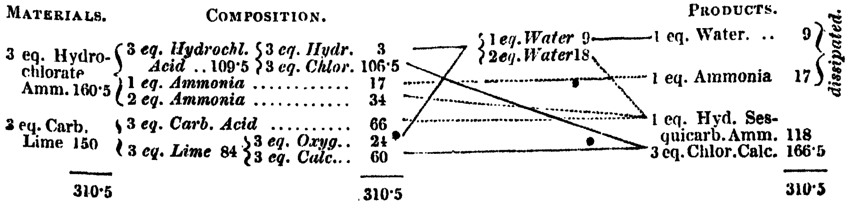
Manufacture of Sesquicarbonate of Ammonia.

a. Retort furnace. *b.* First leaden receiver. *c.* Second ditto. *d.* Refining pots.

All the British Colleges give formulæ for the preparation of this salt. The *London* and *Edinburgh Colleges* order of Hydrochlorate of Ammonia, lb.j., and Chalk lb.iss. These are to be rubbed separately to powder, then mixed, and submitted to sublimation with a heat gradually increased.

In this process three equivalents of sal-ammoniac react on three equivalents of carbonate of lime, and produce an equivalent of the hydrated sesquicarbonate of ammonia, three equivalents of chloride of calcium, one equivalent of ammonia, and one equivalent of water. The chloride of calcium is left in the retort, the hydrated sesquicarbonate of ammonia is sublimed, while the ammonia and the water are dissipated.

If we adopt the old or ammonia theory the equation is as follows: —$3(NH^3, HCl) + 3(CaO,CO^2) = 2NH^3,2HO,3CO^2 + 3CaCl + NH^3 + HO$.



MATERIALS. COMPOSITION. PRODUCTS.

3 eq. Hydrochlorate Amm. 160·5 { 3 *eq. Hydrochl. Acid* ..109·5 { 3 *eq. Hydr.* 3 / 3 *eq. Chlor.* 106·5 ; 1 *eq. Ammonia* .... 17 ; 2 *eq. Ammonia* 34

3 eq. Carb. Lime 150 { 3 *eq. Carb. Acid* .... 66 ; 3 *eq. Lime* 84 { 3 *eq. Oxyg.* .. 24 / 3 *eq. Calc.*.. 60

{ 1 *eq. Water* 9 / 2 *eq. Water* 18

1 eq. Water. .. 9 } *dissipated.*
1 eq. Ammonia 17 } *dissipated.*
1 eq. Hyd. Sesquicarb. Amm. 118
3 eq. Chlor. Calc. 166·5

310·5 310·5 310·5

It appears from experiments presently to be noticed that the compound called sesquicarbonate of ammonia is a double salt, consisting of one equivalent of carbonate and one equivalent of bicarbonate. Now in general, when two neutral salts react on each other, the resulting compounds are also neutral; and, therefore, by the mutual action of 3 equivalents of hydrochlorate of ammonia and 3 equivalents of carbonate of lime, the calculated products should be three equivalents of hydrated neutral carbonate of ammonia (NH^3,CO^2,HO), called hypothetically carbonate of the oxide of the ammonium ($NH^4\,O,\ CO^2$) and 3 equivalents of chloride of calcium ($CaCl$.) But it appears from Rose's experiments that such a hydrated neutral carbonate of ammonia does not exist *per se*. Hence at the commencement of the heating process ammoniacal gas escapes with just so much water as is sufficient to form the hypothetical oxide of ammonium.

If we regard the hydrated sesquicarbonate of ammonia as a double salt, the following equation will explain the reactions on the ammonium theory: $3\,(NH^4, Cl) + 3\,(CaO, CO^2) = (NH^3, CO^2 + NH^4O, 2CO^2, HO) + 3\,CaCl + NH^3 + HO$.

According to Rose,[1] hydrated sesquicarbonate of ammonia cannot be resublimed unchanged. Hence in the process of refining, its constitution changes; every two equivalents lose an equivalent of carbonic acid, and the product is a hydrated $\frac{5}{4}$ carbonate of ammonia.

MATERIAL.	COMPOSITION.		PRODUCTS.	
2 eq. Hydrated Sesqui-carb. Ammonia.. 236	*1 eq. Carbonic Acid..*	22	1 eq. Carbonic Acid ..	22
	5 eq. Carbonic Acid..	110	1 eq. Hydrated $\frac{5}{4}$ Carbonate of Ammonia	214
	4 eq. Ammonia......	68		
	4 eq. Water	36		
236		236		236

PROPERTIES.—Hydrated sesquicarbonate of ammonia is met with in the form of fibrous, white, translucent cakes, about two inches thick. When exposed to the air it evolves carbonate of ammonia, and is converted into bicarbonate of ammonia; so that its vapour has a pungent odour, and strongly reddens turmeric paper. The resulting hydrated bicarbonate is opaque, pulverulent, and much less pungent, from which it has been termed *mild carbonate of ammonia.* The sesquicarbonate is soluble in four times its weight of cold water; but boiling water or alcohol decomposes it, with the evolution of carbonic acid.

Characteristics.—As an ammoniacal salt, this substance is recognised by its odour, its fugacious action on turmeric paper, and by its action on the salts of copper, bichloride of platinum, and bichloride of mercury (see the characteristics for ammonia, p. 420). As a carbonate it is known by its solution yielding a white precipitate (*carbonate of baryta*) with the chloride of barium: the clear liquor from which this precipitate has subsided, yields a further precipitate on the addition of caustic ammonia. By this last character the sesquicarbonate is distinguished from the neutral carbonate. (See *ante,* p. 433.)

COMPOSITION.—This salt consists, according to Mr. Phillips,[2] Dr. J. Davy, Dr. Ure, and Rose, of carbonic acid, ammonia, and water, in the following proportions:—

							Rose.		
	At.	*Eq.Wt.*	*P.Ct.*	*R.Phillips.*	*J.Davy.*	*Ure.*	(*a*)	(*b*)	(*c*)
Carbonic Acid	3	66	55·93	54·2	54·58	54·5	50·55	53·4	56·23
Ammonia	2	34	28·81	29·3	27·39	30·5	28·66	30·7	
Water	2	18	15·26	16·5	18·03	15·0	20·79	15·9	
Hydrated Sesquicarb. of Ammonia	1	118	100·00	100·0	100·00	100·0	100·00	100·0	

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[1] Taylor's *Scientific Memoirs*, vol. ii.

[2] *Quarterly Journal of Science*, vol. vii. p. 294.

Rose's analyses shew that the composition of this salt is not uniform. The differences in the results he explains by the modes of preparing the salt. "When it has been prepared directly by sublimation from carbonate of lime and sal ammoniac or sulphate of ammonia, then it is sesquicarbonate of ammonia. When, however, it has been once more sublimed in the manufactory, probably in order to purify it, it has changed into $\frac{4}{5}$ carbonate of ammonia." In the latter case its composition is as follows :—

	Atoms.	*Eq. Wt.*	*Per Cent.*	*Rose.*
Carbonic acid	5	110	51·40	51
Ammonia	4	68	31·78	31
Water	4	36	16·82	18
$\frac{5}{4}$ Carbonate of ammonia	1	214	100·00	100

Rose suggests that the commercial specimens which he found to be $\frac{5}{4}$ carbonate had been obtained by repeated sublimations, or possibly by one very slow sublimation.

It appears, however, from the observations of Dalton[1] and Scanlan,[2] that it is not a single salt or true sesquicarbonate, but a mixture or compound of the carbonate and bicarbonate; for if treated with a small quantity of cold water, a solution of carbonate is obtained, while a mass of bicarbonate having the form and dimensions of the sesquicarbonate employed, and of which it is a mere skeleton, is left. Two circumstances appear to me to prove that it is not a mere mixture, but a true chemical combination of these salts; viz. first the uniformity of its composition (when prepared in the same way), and secondly its crystalline structure. Its constitution, then, is as follows :—

	At.	*Eq.Wt.*	*P.Ct.*
Anhydrous Carbonate of Ammonia	1	39	33·05
Hydrated Bicarbonate of Ammonia	1	79	66·95
Hydrated Sesquicarbonate of Ammonia	1	118	100·00

or

	At.	*Eq.Wt.*	*P.Ct.*
Anhydrous Carb. of Ammonia	1	39	33·05
Bicarbonate of the oxide of Ammonium	1	70	59·32
Water	1	9	7·63
Hydrated Sesquicarbonate of Ammonia	1	118	100·00

The formula ($NH^4O,CO^2+NH^4O,2CO^2$) is less probable, because the anhydrous carbonate of ammonia is volatilized when the salt is exposed to the air; and also because the bicarbonate of oxide of ammonium always contains water.

IMPURITIES.—The hydrated sesquicarbonate of ammonia of commerce is sometimes contaminated with empyreumatic oil, and in this state it yields a more or less deeply-coloured, or even blackish, solution when dissolved in dilute acid. The pure salt, on the other hand, yields a colourless solution, and leaves no residuum when heated on platinum or glass. It is translucent and crystalline; but when exposed to the air it evolves anhydrous carbonate of ammonia, and becomes opaque, pulverulent, and less pungent: in this state it consists principally of bicarbonate of the oxide of ammonium. Lastly, its aqueous solution, saturated with pure nitric acid, gives no precipitate with solution either of chloride of barium or of nitrate of silver; for a precipitate with the first of these substances would indicate the presence of a sulphate, with the second a chloride. If any hyposulphite of ammonia be present, the salt, when neutralized by acetic acid, yields with the nitrate of silver a precipitate which is at first white, but becomes black. The presence of lead (derived from the leaden receivers used in its manufacture) is recognised by dissolving the salt in diluted nitric acid and testing with sulphuretted hydrogen, which produces a dark or black coloration or precipitate, if lead be present.

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[1] *Memoirs of the Literary and Philosophical Society of Manchester,* 2d ser. vol. iii. p. 18.
[2] *Athenæum* for 1838, p. 596.

PHYSIOLOGICAL EFFECTS. *a. On Animals.*—The principal experimenters with this salt are Seybert, Orfila, and Gaspard, on dogs, and Wibmer on man. Seybert[1] injected in one experiment fifteen grains, in a second twenty-five grains, and in a third experiment forty-five grains of this salt, dissolved in a little water, into the crural vein of a dog: the animal appeared to suffer great pain; the frequency of the heart's action was increased, the respiration became difficult, and violent convulsions came on; but in all these cases perfect recovery took place. The blood, drawn after the injection, had its natural colour, odour, and consistence. Orfila[2] found that two drachms and a half of the salt, given to a dog, caused gastric inflammation, with tetanic convulsions; the body ultimately becoming curved, with the head forcibly bent backwards. Gaspard (quoted by Wibmer[3]) killed a young pig, of three weeks old, by injecting twenty-four drops of (a solution of) carbonate of ammonia in an ounce of water into the veins. Death occurred in nine hours.

β. On Man.—Wibmer found that a grain and a half of this salt produced on himself no remarkable effect; three grains increased the frequency of the pulse from 68 to 72 beats per minute, with throbbing headache. In other experiments, in which he took from six to twelve grains (in some repeating the dose at short intervals), the effects were usually, but not constantly, increased frequency of pulse, with disorder of brain, manifested by the pain, heaviness, throbbing, &c. In one instance, he says, disposition to cough, and increased secretion of bronchial mucus, were remarkable. To an epileptic patient (a female) in the London Hospital, I gave fifteen grains of this salt three times a day for two months, without any apparent injury. The fits, which previously had occurred at stated periods, were suspended during the time the patient was under the influence of the medicine. I have repeatedly given a scruple of this salt three times daily for two or three weeks without any ill effect: on the contrary, with great benefit in hysterical and epileptical complaints. Huxham[4] has mentioned a remarkable case illustrative of the ill effects resulting from the long-continued use of this salt.

> "I had lately under my care," he observes, "a gentleman of fortune and family, who so habituated himself to the use of vast quantities of volatile salts, that at length he could eat them in a very astonishing manner, as other people eat sugar and caraway seeds. The consequence was that he brought on a hectic fever, vast hæmorrhages from the intestines, nose, and gums; every one of his teeth dropped out, and he could eat nothing solid; he wasted vastly in his flesh, and his muscles became as soft and flabby as those of a new-born infant; and he broke out all over his body in pustules. His urine was always excessively high coloured, turbid, and very fetid. He was at last persuaded to leave off this pernicious custom; but he had so effectually ruined his constitution, that, though he rubbed on in a miserable manner for several months, he died, and in the highest degree, of marasmus. And I am persuaded he would have died much sooner, had he not constantly drank very freely of the most fine and generous wines, and daily used large quantities of asses' milk, and anti-scorbutic juices, acidulated with juice of lemon."

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[1] Quoted by Wibmer, *Die Wirkung*, &c.

[2] *Toxicol. Générale.*

[3] *Die Wirkung*, &c.

[4] *Essay on Fevers*, pp. 48 and 308, 3d edit. Lond. 1757.

The general action of this salt is similar to that of caustic ammonia, already noticed. Its topical operation, however, is less intense; for combination with carbonic acid diminishes the local action of ammonia in proportion to the quantity of acid present.

In small doses it proves antacid, stimulant, and sudorific. By repeated use it operates as a resolvent or liquefacient spanæmic (see *ante*, p. 175), like the other alkalines (see *ante*, p. 176), though much less intensely so. In doses of thirty grains or more it is apt to occasion vomiting. The effects of an over-dose are abdominal pains, and other symptoms of inflammation, convulsions, and other phenomena indicative of its action on the nervous system.

USES.—It is used in similar cases and under the same regulations as the solution of ammonia (see *ante*, p. 427).

In *epilepsy* I have extensively employed it, and in many cases with obvious benefit. It should be given in large doses in properly diluted solutions: to adults from ten grains to a scruple. It frequently proves successful in hysterical epilepsy, and in that syncopal form of epilepsy which Sauvages called lipothymia, and which patients describe as "dying away," but the connection of which with ordinary epilepsy is shown by its occasional transition into the latter.

In *hysteria* also it is one of our most useful and valuable remedies; given either alone or in combination with a bitter infusion.

Recently this salt has been recommended, by Dr. Barlow,[1] in *diabetes*, several cases of which are said to have been relieved, if not cured, by it. I regret that I cannot confirm Dr. Barlow's favourable notice of it. Although in some cases I have seen patients temporarily improve under its use, yet the amendment has been brief, and was probably referable to other circumstances. In some cases no benefit whatever has attended its employment. In one case (that of a man, an out-patient at the London Hospital) it failed to give any relief, after a very prolonged trial.

It has been employed with excellent effect in some cases of *scrofula*.[2] It is best adapted for those cases attended with a languid circulation and a dry state of skin.

It has been recommended by Peyrilhe to relieve venereal pains and nodes.[3]

It is frequently employed for the preparation of effervescing draughts. The following are the relative proportions of acid and base to be used:—

20 grains of Sesquicarbonate of Ammonia require	6	fluidrachms of Lemon Juice, or
	24	grains of crystallized Citric Acid, or
	25½	grains of crystallized Tartaric Acid.

The citrate and tartrate of ammonia thus obtained are useful remedies in febrile cases, where the object is to promote cutaneous circulation and exhalation.

Full doses of this salt have been employed in *paralysis*, to occasion vomiting.

Mixed with some aromatic oil (as the oil of bergamot or lavender), it is used as a *smelling salt*, against syncope, hysteria, &c. (see *ante*, p. 435).

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[1] *Guy's Hospital Reports*, vol. v.

[2] *An Essay on Scrophula, in which an Account of the Effect of the Ammoniæ Carbonas, as a Remedy in that Disease, is submitted to the Profession*, by Charles Armstrong, M.D. Lond. 1812.

[3] Pearson's *Observations on the Effects of various Articles of the Materia Medica in the Cure of Lues Venerea*, Lond. 1800.

As a topical agent it has been employed in aqueous solution, or mixed with oil to form an imperfect kind of soap, or to make into ointment with lard. Its operation in these cases is that of a topical stimulant and rubefacient. It proves useful in rheumatic pains, sprains, &c.

ADMINISTRATION.—As a stimulant and diaphoretic, it is used in doses of from five grains to a scruple. It is usually given in solution, but sometimes in the form of pill. As an emetic, the dose is thirty grains, properly diluted, and repeated if necessary.

ANTIDOTES.—See *Ammonia*, p. 430.

1. LIQUOR AMMONIÆ SESQUICARBONATIS, L. *Ammoniæ Carbonatis Aqua*, E. D. (Sesquicarbonate of Ammonia, ℥iv. [4 parts, *D.*]; Distilled Water, Oj. [15 parts, *D.*] Dissolve and filter).—By exposure to the air, this solution loses its pungency by the formation of bicarbonate of ammonia. It may be given internally in doses of from fʒss. to f℥iss., or even f℥ij. properly diluted. It is employed in the preparation of Ferri Potassio-tartras, *Ph. L.*, and is a constituent of the following liniment:—

2. LINIMENTUM AMMONIÆ SESQUICARBONATIS, L. *Liniment of Sesquicarbonate of Ammonia.* (Solution of Sesquicarbonate of Ammonia, f℥j., Olive Oil, f℥iij. Shake them together until they are mixed).—Oil and sesquicarbonate of ammonia form a soap, but, owing to the presence of the carbonic acid, it is of an imperfect kind. Its effects and uses are analogous to the *Linimentum Ammoniæ* before mentioned (p. 430).

3. AMMONIÆ SESQUICARBONAS PYRO-OLEOSA; *Ammoniacum carbonicum pyro-oleosum*, Ph. Boruss.; *Sal Volatile Cornu Cervi*; *Empyreumatic Sesquicarbonate of Ammonia*; *Volatile Salt of Hartshorn.*—(Powdered Sesquicarbonate of Ammonia, ℥viii.; gradually add of Dippel's Oil, ʒij., carefully mix, and preserve the yellow powder in a well-stoppered bottle).—This is a substitute for the old salt of hartshorn. It is a very powerful stimulant and antispasmodic; and is employed in epilepsy, hysteria, asthma, typhus, paralysis, chronic rheumatism, &c. Dose gr. v. to gr. x. Usually given in solution; now and then in powder or pill.

3. Ammoniæ Bicarbonas.—Bicarbonate of Ammonia.

Formula $NH^3,2CO^2,2HO$; or $NH^4O,2CO^2,HO$. *Equivalent Weight* 79.

HISTORY.—This salt was formed by Berthollet,[1] and hence it is sometimes termed *Berthollet's neutral carbonate of ammonia.* It is also called the *hydrated bicarbonate of the oxide of ammonium.*

PREPARATION.—The directions of the Dublin College for its preparation are as follows:—

"Take of Water of Carbonate of Ammonia any required quantity. In a suitable apparatus let the water be exposed, until the alkali is saturated, to the stream of Carbonic Acid Gas which escapes during the solution of white marble in diluted Muriatic Acid. Then let it rest, and let crystals form, which are to be dried without heat, and preserved in a close vessel."

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[1] *Journ. de Physique*, Feb. 1807, p. 173.

The formation of crystals is promoted by forcing the carbonic acid gas into the solution by pressure.

Bicarbonate of Ammonia is also formed by keeping the common sesquicarbonate of ammonia in imperfectly closed vessels. Another mode of obtaining it is by digesting water on the sesquicarbonate: the more soluble carbonate is dissolved, leaving the less soluble bicarbonate (see *ante*, p. 439).

PROPERTIES.—The crystals of this salt have, according to Rose, the same form as those of bicarbonate of potash. Their smell and taste are very faintly ammoniacal. By its faintly ammoniacal smell, Rose thinks that it indicates a tendency to pass into the $\frac{9}{4}$ carbonate. This salt is less soluble in water than the preceding carbonates; for it requires eight parts of cold water to dissolve it. The solution, by exposure to the air, loses part of its carbonic acid, especially if it be heated.

Characteristics.—It is distinguished from the before-mentioned carbonates by having scarcely any ammoniacal odour. Its solution at first occasions no precipitate with chloride of barium or chloride of calcium (unless caustic ammonia be added): after a short time, or on the addition of some caustic ammonia, however, the mixture evolves carbonic acid, and a white earthy carbonate is precipitated (see *ante*, p. 433).

COMPOSITION.—The composition of this salt is as follows:—

	At.	*E.Wt.*	*P.Ct.*	*Phillips.*	*Rose.*
Ammonia	1	17	21·5	21·16	21·39
Carbonic Acid	2	44	55·7	55·50	56·09
Water	2	18	22·8	23·34	22·52
Crystallized Bicarbonate of ammonia	1	79	100·0	100·00	100·00

or

	At.	*E.Wt.*	*P.Ct.*
Oxide of Ammonium	1	26	33·0
Carbonic Acid	2	44	55·7
Water	1	9	11·3
Hydrated Bicarbonate of Ammonium	1	79	100·0

Rose has described two other bicarbonates of ammonia, one with two and a half, another with three atoms of water. The former ($NH^3,2CO^2, 2\frac{1}{2}HO$) is obtained by pouring as much boiling water over the common sesquicarbonate as is sufficient to dissolve this salt, and immediately covering the vessel to prevent the escape of carbonic acid. Large crystals of the bicarbonate are produced on the surface of the liquor on cooling. These Rose thinks have been mistaken for the bicarbonate with two atoms of water. They are distinguished by the form of the crystals (which are those of right rhombic prisms) and by the quantity of water which they contain.

PHYSIOLOGICAL EFFECTS.—The effects of this salt are analogous to those of the preceding compounds of ammonia. It is diaphoretic, antispasmodic, and antacid. Being less caustic, it is more palatable than the other carbonates.

USES.—It is employed in the same cases as the sesquicarbonate. It is sometimes used to form effervescing medicines. About 18 grs. of Citric, or 19 grs. of Tartaric Acid, are required to saturate ℈j of this salt.

ADMINISTRATION.—The dose of it is from ten grains to half a drachm dissolved in *cold* water.

31. AMMONIÆ HYDROCHLORAS.—HYDROCHLORATE OF AMMONIA.

Formula NH^3,HCl or NH^4,Cl. *Equivalent Weight* 53·5.

History.—The early history of this salt is involved in considerable obscurity; for though the term *sal ammoniacus* (ἅλς ἀμμωνιακός) is met with in several old writers, it is believed, by the erudite Beckmann[1] as well as by others, to refer to rock-salt. The first distinct notice of hydrochlorate of ammonia is to be met with in Geber, who was acquainted with the mode of purifying it by sublimation. But, as my friend Dr. Royle observes,[2] this salt must have been familiar to the Hindoos ever since they have burnt bricks, as they now do, with the manure of animals; as some may usually be found crystallized at the unburnt extremity of the kiln."

The substance, whatever its name may be, which the ancients termed sal ammoniac, derived its name from *Ammonia*, the name of a district of Libya where the oracle of Jupiter Ammon was situated. This district is usually said to have taken its name from ἄμμος, *sand*, on account of the sandy nature of its soil: but it is, perhaps, derived from ἄμμων, a word of Egyptian origin (see Liddell and Scott's *Greek Lexicon*). Herodotus[3] mentions the salt found in this district.

Synonymes.—Few substances have had so many synonymes as this salt.[4] Its most familiar names are, *sal ammoniac* or *muriate of ammonia* (*ammoniæ murias*). On the ammonium hypothesis it is called *chloride of ammonium*, while, according to Dr. Kane, it is the *chloro-amidide of hydrogen*.

Natural History.—See *Ammonia*, 419.

Preparation.—In Eygpt, sal ammoniac is obtained by sublimation from the soot afforded by the combustion of camel's dung[5] (*sal ammoniacus Ægyptiacus*).

It is probable that the muriatic acid or chlorine of this salt is derived from the common salt on which these animals feed; for Chaptal[6] says that he could only procure sal ammoniac from the soot of cow-dung and that of horses while these animals continued to live on marine plants.

Some years ago this salt was manufactured in London from the soot of coals. At the latter end of the last century it was made in Paris by the union of ammoniacal vapour (obtained by the decomposition of animal matters, in iron cylinders placed in a furnace) with muriatic acid gas.[7]

At Liege it is obtained by sublimation from the soot obtained by burning, in peculiar ovens, a mixture of coals, common salt, animal matter, and clay (L. Gmelin).

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[1] *History of Inventions*, vol. iv. p. 306, Lond. 1814.

[2] *Essay on the Antiquity of Hindoo Medicine*, p. 41, Lond. 1837.

[3] Lib. iv. [*Melpomene*], cap. 181-2.

[4] For the alchymical names of this subject, see Dr. T. Thomson's *History of Chemistry*, vol. i. p. 121, Lond. 1830; and Parr's *Medical Dictionary*, art. *Ammoniacus*.

[5] A very full and complete description of the process, with illustrative plates, will be found in the splendid *Description de l'Egypte*, Etat Moderne, tom. i. p. 413, Paris 1809; planches ii. and xxiv. Arts et Métiers. See also Parkes's *Chemical Essays*, 2d edit. vol. ii. p. 437, Lond. 1823.

[6] *Elements of Chemistry*, vol. i. p. 262, Lond. 1791.

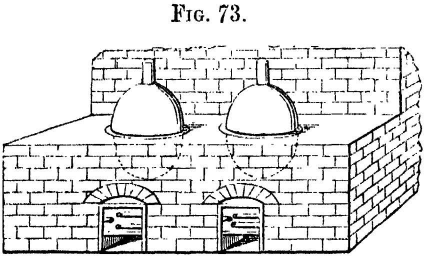
[7] See *Journal de Physique* for 1794. Also Parkes, *op. supra cit.*

At the present time sal ammoniac is manufactured in this country from the impure ammoniacal liquors obtained as secondary products in the manufacture of coal gas and animal charcoal.

1. Manufacture of Sal Ammoniac from Coals.—In the manufacture of coal gas, coal is submitted to distillation in iron retorts, and the volatile matters obtained are conveyed to a condensing vessel or refrigeratory, in which are deposited tar and an ammoniacal liquor.

This ammoniacal liquor (commonly termed *gas liquor*) contains several salts of ammonia—such as carbonate, sulphate, hydrosulphate, &c. It is usually sold to sal-ammoniac manufacturers, who reside in the outskirts of the metropolis. The precise mode of proceeding, to convert it into sal ammoniac, varies according to circumstances. Sometimes sulphuric acid is added, and the liquor evaporated, by which brown crystals of sulphate of ammonia are obtained. This salt is then mixed with chloride of sodium, and submitted to distillation in iron pots lined with clay, to which are adapted leaden domes or heads, each having an aperture or open cylindrical tube, which can be closed or opened according to circumstances (fig. 73).

FIG. 73.



Sublimation of Hydrochlorate of Ammonia.

A few years since, on examining the clay removed from the pots after the operation, I discovered small, but distinct and beautiful, crystals of the bisulphuret of iron, which had been formed during the process.

One equivalent of sulphate of ammonia reacts on one equivalent of chloride of sodium, and yields one equivalent of sal ammoniac, and one equivalent of sulphate of soda. On the old or ammonia theory, the equation is as follows: $HN^3,SO^3,HO + NaCl = NH^3,HCl + NaO,SO^3$.

MATERIALS.		COMPOSITION.		PRODUCTS.	
1 eq. Sulphate of Ammonia	66	*1 eq. Ammonia*	17	1 eq. Hydrochlor. Ammonia ..	53·5
		1 eq. Sulphuric Acid	40		
		1 eq. Water, 9 — *1 eq. Hydrog.*	1		
		1 eq. Oxygen	8		
1 eq. Chloride of Sodium	58·5	*1 eq. Chlorine*	35·5		
		1 eq. Sodium	23	1 eq. Sulph. Soda	71
	124·5		124·5		124.5

On the ammonium theory, the equation is as follows:—$NH^4,O,SO^3 + NaCl = NH^4Cl + NaO,SO^3$. In some cases the gas liquor is saturated with hydrochloric acid, and the brown crystals of hydrochlorate of ammonia obtained by evaporation are purified by sublimation.

As a cheap substitute for hydrochloric acid, manufacturers sometimes employ an impure chloride of calcium.[1] This proceeding I have seen adopted at a manufactory on Bow Common; and the process has been described by my friend and former pupil, Dr. G. H. Jackson[2]: it is as follows:—

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[1] The chloride of calcium used in the above process is a secondary product, obtained, I am informed, from salt-works. It contains the chlorides of sodium and magnesium.

[2] *London Medical Gazette*, Aug. 4, 1839.

To the gas liquor, chloride of calcium is added, when a copious precipitation of carbonate of lime takes place, sal ammoniac being left in solution. The whole of this is put into a tub, having holes in the bottom to allow the solution to drain through, leaving the solid particles behind. This solution is evaporated at a gentle temperature in iron tanks, when it yields impure crystals of sal ammoniac, of a brownish colour. The salt is then dried, and the water of crystallization driven off in a long iron vessel, very similar to a sand-bath. It is now placed in an iron subliming pot (previously coated to the extent of from one to five inches in thickness, with a composition of common clay, sand, and charcoal), capable of holding about 5 cwts. This is covered by a dome of lead, with an aperture at the top, in which a stopper is placed, by the removal and appearance of which the manufacturer judges of the progress of the sublimation. A gentle fire is kept up under the subliming pot for seven or eight days, when the dome having cooled down, and the sal ammoniac somewhat contracted, so as to loosen from the sides, the dome is thrown off from the iron pot, and about 2 or 3 cwts. of white, semi-transparent, sal ammoniac are knocked off in cakes.

I have seen cakes of sal ammoniac, made at the same manufactory by this process, weighing between 5 and 6 cwts. each; and I am informed that they sometimes weigh 1000 lbs. each. They are discoloured on their convex surface (in contact with the leaden dome), and are, therefore, carefully scraped before being sent out.

The grey salt scraped from the exterior of the cakes consists of, or at least yields, hydrochloric acid, ammonia, and lead. A solution of the purified salt yields no iodide of lead on the addition of iodide of potassium, but affords a black precipitate (sulphuret of lead) when sulphuretted hydrogen gas is passed through it. It is probably a *double chloride of lead and ammonium.*[1]

Yellow or brownish streaks or bands are frequently observed in the cakes of sal ammoniac. These are ascribed by the manufacturers to the neglect of the workmen, who, falling asleep during the night, allow the fire to go down considerably, and then suddenly raise the heat, by which chloride of iron is sublimed in combination with sal ammoniac.

For several years past I have been accustomed to demonstrate in the lecture-room that a solution of these yellow bands in water gives no traces of iron on the addition of ferrocyanide of potassium, until a few drops of nitric acid be added, when a copious blue precipitate is formed; and I therefore inferred that this yellow matter was a *double chloride of iron and ammonium.* My opinion has been fully confirmed by the experiments of Dr. G. H. Jackson.

2. Manufacture of Sal Ammoniac from Bones.—Sal ammoniac is also manufactured from the ammoniacal liquor (called *bone spirit,*) obtained as a secondary product during the production of animal charcoal (see *ante,* p. 312).

Manufacturers of animal charcoal usually sell their bone spirit to makers of sal ammoniac, who adopt different modes of proceeding, according to circumstances. Sometimes sal ammoniac is made from bone spirit in the same way as from gas liquor. Some manufacturers digest the bone spirit with ground plaster of Paris (sulphate of lime), by which carbonate of lime and sulphate of ammonia are formed; the former is precipitated, the latter remains in solution. The liquor being filtered and evaporated yields brown crystals of sulphate of ammonia, which, being mixed with common salt, is submitted to sublimation, by which sulphate of soda and sal ammoniac are obtained.

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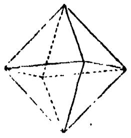
[1] Dr. Jackson, *London Medical Gazette,* Aug. 4, 1839.

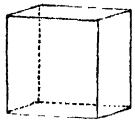
PROPERTIES.—Hydrochlorate of ammonia usually occurs in commerce in the form of large hemispherical cakes which have a round hole in the centre, (*sal ammoniacus sublimatus*). They are translucent, and by exposure to the atmosphere become slightly moist. By solution or resublimation it may be obtained in regular octohedral or cubic, or plumose crystals, formed of rows of minute octohedrons, attached by their extremities (*refined sal ammoniac; sal ammoniacus depuratus; flores salis ammoniaci*). The Brunswick sal ammoniac is in the form of sugar loaves. The sp. gr. of sal ammoniac is 1·450. Its taste is saline and acrid; it has no odour. When heated, it sublimes without undergoing fusion or decomposition. It is soluble in about 3 parts of cold and 1 of boiling water: cold being produced during the solution. It dissolves in alcohol.

FIG. 74.



Regular Octohedron.

FIG. 75.



Cube.

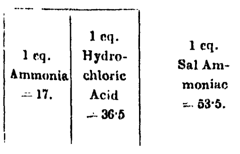
Characteristics.—It may be recognised by the following characters: it is white and volatile; and if heated on the point of a knife by the flame of a candle, it readily sublimes. Mixed with caustic potash, or quicklime, it evolves ammoniacal gas, which is known by its odour, its action on turmeric paper, and its fuming with the vapour of hydrochloric acid (see *ante*, p. 420). Dissolved in water, the hydrochlorate of ammonia produces, with a solution of nitrate of silver, a white precipitate of silver, recognised by the properties before described (see *ante*, p. 369); and with bichloride of platinum a yellow precipitate which, when collected, dried, and ignited, yields spongy platinum (see *ante*, p. 421).

COMPOSITION.—The following is the composition of this salt on the old or ammonia theory:—

	Atoms.	*Eq. Wt.*	*Per Cent.*	*Berzel.*	*Kirwan.*	*Bucholz.*
Ammonia	1	17	31·78	31·95	25	31
Hydrochloric Acid	1	36·5	68·22	68·05	75	69
Hydrochlorate Amm.	1	53·5	100·00	100·00	100	100

	Vol.
Ammoniacal gas	2
Hydrochloric Acid gas	2

If one equivalent or two volumes of hydrochloric acid gas be mixed with one equivalent or two volumes of ammoniacal gas, combination is effected; the gases disappear, heat is evolved, and the white hydrochlorate is deposited.



According to Berzelius, sal ammoniac is *chloride of ammonium*, NH^4,Cl; while, according to Dr. Kane, it is a *chloro-amidide of hydrogen* (see *ante*, p. 421). The composition of sal ammoniac, according to these hypothetical notions, is as follows:—

	Atoms.	*Eq. Wt.*	*Per Ct.*
Chlorine	1	35·5	66·35
Ammonium	1	18	33·65
Chloride of Ammonium	1	53·5	100·00

or

	Atoms.	*Eq. Wt.*	*Per Ct.*
Chloride of Hydrogen	1	36·5	68·22
Amidide of Hydrogen	1	17	31·78
Chloro-amidide of Hydrogen	1	53·5	100·00

IMPURITIES.—Hydrochlorate of ammonia is sometimes rendered impure by the presence of iron, or of lead: the modes of recognising which, have been already pointed out (see *ante*, p. 446).

PHYSIOLOGICAL EFFECTS. *a. On Vegetables.*—According to Sir H. Davy,[1] water holding in solution $\frac{1}{300}$th of its weight of hydrochlorate of ammonia promotes vegetation. Solutions which contained $\frac{1}{30}$th of their weight of this salt he found injurious.

β. On Animals.—Courten,[2] Sprögel, Viborg, and Gaspard (quoted by Wibmer),[3] injected solutions of sal ammoniac into the veins of animals (dogs and horses): large doses generally caused convulsions, sometimes paralysis, and death. From the observations of Orfila, Smith, Arnold,[4] and Moiroud,[5] this salt appears to be a local irritant; and, when introduced into the stomach in large quantities, causes vomiting, purging, and gastro-enteritis. It exercises a specific influence over distant organs; for the first three of the above-mentioned experimenters observed that inflammation of the stomach ensued, to whatever part of the body the salt might have been applied, and the convulsions and paralysis above referred to attest its action on the nervous system. Arnold says it diminishes the plasticity of the blood.

γ. On Man.—Its local action is that of an irritant. Its chemical influence is not very obvious. It dissolves mucus, but does not coagulate albumen. Its action on the general system is that of a liquefacient and resolvent (see *ante*, p. 175), similar to that of the other neutral salts (see *ante*, p. 178). Wibmer tried this salt on himself. He took from ten to twenty grains for a dose, which he repeated at the end of an hour. The effects were a sensation of warmth and oppression in the stomach, headache, and increased desire of passing the urine.

In this country it is so rarely employed internally that we have very slight experience either of its physiological or of its therapeutical effects. In Germany, where it is more frequently administered, it is in high repute as a powerful alterative or resolvent. "Like most salts," says Sundelin,[6] "sal ammoniac operates on the alimentary canal as an excito-irritant. After its absorption it appears to reduce moderately the action of the heart and large arteries, and, in this respect, belongs to debilitating or temperant agents. But it acts as excitant and irritant to the venous and arterial capillary systems, to the lymphatic vessels and glands, to the skin, to the kidneys, and especially to the mucous membranes; not only increasing secretion, but also improving nutrition and assimilation, and counteracting organic abnormal conditions (as tumors, thickenings, and relaxations), so frequently met with in those structures. It promotes not only the mucous secretions but also cutaneous exhalation, and even menstruation. Its diuretic effects are less obvious. It extends its stimulating influence to the serous and fibrous tissues, whose nutrition it improves.

"From these statements it follows that sal ammoniac operates like the more powerful alterative agents. In some respects it resembles mercury; but is less liquefacient and resolvent on the organic textures, and less stimulant to the lymphatic vessels, than the latter agent. Its long-continued use may, indeed, injure the digestive powers, but never gives rise to general cachexia. I have administered large doses of it against thickening of the mucous membrane for months, without remarking any injurious effects beyond those just mentioned. In large doses it purges like other salts, but in small ones rather constipates."

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[1] *Agricultural Chemistry.*

[2] *Phil. Trans.* for 1712.

[3] *Die Wirkung*, &c.

[4] Wibmer, *op. cit.*

[5] *Pharmacol. Vétérinaire.*

[6] *Handbuch der speciellen Heilmittellehre*, 1er Bd. S. 150, 3te Aufl.

Kraus[1] says that a slight miliary eruption and very painful aphthæ have been produced by large doses of it.

USES.—In this country it is rarely employed internally. In Germany, where it is frequently used, it is administered in the following cases:—

1. *In mild inflammatory fevers*, especially those complicated with affections of the mucous or fibrous membranes, as in the diseases called bilious, gastric, catarrhal, or rheumatic fevers, it is employed for promoting secretion and hastening critical discharges.

2. *In inflammation of the mucous or serous membranes*, as catarrh, dysentery, urethritis, peritonitis, pleuritis, &c. when the first violence of the disease has been subdued, but when the secretions and exhalations are not yet established. In these cases it is used as a substitute for mercury.

3. *In chronic diseases* of various kinds, as chronic inflammation of the lungs, liver, and spleen; enlargement of the mesenteric glands; induration of the prostate, uterus, and ovaries; catarrhus vesicæ; chronic ulceration of the uterus; mucous discharges from the urethra and vagina, it is administered as an alterative, as a stimulant to the absorbent system, and as a promoter of healthy secretion.

4. *In amenorrhœa* it is strongly recommended by Sundelin as an emmenagogue in those cases in which the disease depends on, or is connected with, inactivity of the uterus.

Externally it is sometimes employed, on account of the cold produced during its solution, in headache, inflammatory affections of the brain, mania, apoplexy, &c. When used for this purpose it must be applied as soon as the salt is dissolved. Mr. Walker[2] found that five parts of this salt, with five parts of nitrate of potash and sixteen parts of water, lowered the thermometer from 50° to 10° F. A *freezing mixture* of this kind placed in a bladder has been recommended by Sir A. Cooper as an application (*ice-poultice*) to hernial tumors, as I have already mentioned (see *ante*, p. 34). It may be applied, instead of the ice-cap before noticed (p. 34), to the head.

As a stimulant and resolvent, or discutient, sal ammoniac is used in the form of *plaster* or *lotion*. In powder it is sometimes employed as a dentifrice. A solution of ℥ss. in f℥xij. of water is used as a gargle. In these cases it is probably not better than common salt.

It is occasionally used to augment the solubility of bichloride of mercury, with which it combines to form a soluble double salt (see *liquor hydrargyri bichloridi*). Tobacconists use it in the manufacture of snuff.

ADMINISTRATION.—For internal use the dose of it is from five to thirty grains every two or three hours, either in a pulverulent form, combined with sugar or gum, or in solution with some saccharine or mucilaginous substance, to which an aromatic should be added.

ANTIDOTE.—In the event of poisoning by this salt, warm water and mucilaginous and demulcent liquids should be given to promote vomiting.

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[1] *Heilmittellehre*, S. 309, Göttingen, 1831.

[2] *Phil. Trans.* 1801, p. 120.

No chemical antidote or counterpoison is known. Gastro-enteritis is, of course, to be combated by the usual means.

1. **LOTIO AMMONIÆ HYDROCHLORATIS**; *Muriate of Ammonia Wash.*—A solution of sal ammoniac in water or in vinegar, with or without the addition of rectified spirit, is used as a resolvent or discutient lotion or embrocation. The proportions of the ingredients vary according to circumstances. When a strong lotion is required, from one to two ounces of the salt are dissolved in twelve fluid-ounces of liquid. Four ounces of rectified spirit are sometimes added. A wash of this strength is used in contusions and ecchymosis when there is no wound of the skin; in chronic tumors of the breast; in white swellings and other chronic affections of the joints; in hydrocele and dropsical enlargement of the thyroid gland; in chilblains; in sphacelus after the requisite scarifications, &c. Weaker solutions (as from ʒj. to ʒiv. of the salt in Oj. of water) are employed as washes in scabies and ulcers, and as injections in gonorrhœa and leucorrhœa.

2. **EMPLASTRUM AMMONIÆ HYDROCHLORATIS**; *Sal Ammoniac Plaster.* Lead plaster, ℥ss., Soap, ʒij.; melt them together, and when nearly cold, add Hydrochlorate of Ammonia, ʒss., in fine powder.)—This plaster is stimulant and rubefacient. Its efficacy depends on the evolution of ammoniacal gas, in consequence of the action of the alkali of the soap on the hydrochloric acid of the sal ammoniac: hence it requires renewal every twenty-four hours. It is employed as a discutient for chronic swellings and indurations, white swellings, &c. Dr. Paris[1] recommends it in rheumatism of the muscles of the chest and in pulmonary complaints.

32. AMMONIÆ HYDROSULPHATES.—HYDROSULPHATES OF AMMONIA.

HISTORY.—Four ammoniacal compounds of sulphur and hydrogen are known. They are as follows:—

1.	Hydrosulphate of ammonia or sulphuret of ammonium .	NH^3,HS or NH^4,S
2.	Bihydrosulphuret of ammonia, or hydrosulphuret of the sulphuret of ammonium	$NH^3,2HS$ or $NH^4,S+HS$
3.	Pentasulphuret of ammonium	NH^3,HS,S^4 or NH^4,S^5
4.	Heptasulphuret of ammonium	NH^3,HS,S^6 or NH^4,S^7

Besides the preceding, there is a fifth compound, commonly called *Boyle's fuming liquor of sulphur*, the precise composition of which is doubtful.

Of the preceding compounds, two only have been employed in medicine: these are the bihydrosulphate (commonly called hydrosulphuret of ammonia), and Boyle's fuming liquor of sulphur.

NATURAL HISTORY.—Privies, drains, sewers, and other receptacles of decomposing animal matter, evolve hydrosulphuret of ammonia along with sulphuretted hydrogen and nitrogen.

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[1] *Pharmacologia.*

1. Ammoniæ Bihydrosulphas.—Bihydrosulphate of Ammonia.

HISTORY.—This is the compound which, under the name of *hepatized ammonia*, was employed by Dr. Rollo,[1] at the latter end of the last century, in the treatment of diabetes; for Mr. Cruickshank[2] states that it was prepared by passing sulphuretted hydrogen gas through liquor ammoniæ until no farther absorption was perceived, or until the alkali was saturated. It is this compound to which the name of *hydrosulphuret of ammonia* (*ammoniæ hydrosulphuretum*, Ph. Dub.) is usually applied, and which is commonly employed as a test. It is sometimes called the *hydrosulphuret of the sulphuret of ammonium*, or the *sulpho-hydrate of ammonium*, or the *double sulphuret of ammonium and hydrogen*.

PREPARATION.—The crystallized salt is obtained by mixing equal measures of ammoniacal and sulphuretted hydrogen gases in a vessel surrounded by ice.—For medicinal and pharmaceutical purposes, an aqueous solution of this salt is employed. This is prepared by saturating liquor ammoniæ, diluted with three times its bulk of water, with hydrosulphuric acid (sulphuretted hydrogen) gas. The gas should be washed before it passes into the ammoniacal solution by passing it through water contained in a small bottle; otherwise a portion of the iron liquor is apt to pass over with the gas.

The following are the directions given by the Dublin College for the preparation of this compound:—

Take of Sulphuret of Iron, reduced to a coarse powder, five parts; Sulphuric Acid, seven parts; Water, thirty-two parts; Water of Caustic Ammonia, four parts. Pass the sulphuret into a retort, then gradually pour on it the acid, first diluted with water, and, in a suitable apparatus, cause the elastic fluid to pass through the water of ammonia. Toward the end of the process, apply a moderate heat to the retort.

The changes which attend the action of dilute sulphuric acid on sulphuret of iron have been already explained (see *ante*, p. 363).

The hydrosulphuric acid gas, when conveyed into a solution of ammonia, combines with it to form the bihydrosulphuret of ammonia. $2HS + NH^3 = NH^3,2HS$. According to the ammonium theory, the hydrosulphuret of the sulphuret of ammonium is produced, $NH^4,S + HS$.

When the solution of ammonia is completely saturated with sulphuretted hydrogen gas, it ceases to occasion a precipitate in a solution of sulphate of magnesia. If, however, it be incompletely saturated, it produces a precipitate with, or renders turbid a solution of, this salt.

NEUTRAL HYDROSULPHURET OF AMMONIA; *Neutral sulphuret of ammonium.*—If one portion of aqua ammoniæ be saturated with hydrosulphuric acid (sulphuretted hydrogen) gas, and then mixed with another and equal portion of aqua ammoniæ, we obtain the neutral hydrosulphate of ammonia. NH^3,HS; or NH^4,S.

PROPERTIES.—Solid bihydrosulphuret of ammonia occurs in acicular and foliated crystals, which have the combined odour of ammonia and sulphuretted hydrogen. They have an alkaline reaction, and are volatizable at ordinary temperatures.

The officinal solution commonly called the hydrosulphuret of ammonia is a liquid having a very fetid odour and an acrid disagreeable taste. The mineral acids decompose it and evolve hydrosulphuric acid gas. It forms with a considerable number of metallic solutions precipitates. With the salts of lead, bismuth, silver, and copper, the precipitates are blackish; with those of antimony, red; with those of cadmium and tin (persalts), and with the arsenites (on the addition of an acid), yellow; lastly, with the salts of zinc, white. In these cases the precipitates are either sulphurets or hydrated sulphurets of the respective metals.

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[1] *Cases of the Diabetes Mellitus*, 2d edit. Lond. 1798.
[2] *Ibid.* p. 52.

By keeping in bottles made of flint-glass, it gives rise to the formation of a thin coating of black sulphuret of lead on the inside of the bottle.

Characteristics.—It is readily known to be a compound of sulphuretted hydrogen and ammonia by its odour. As a sulphuret or hydrosulphuret, it is known by its evolution of sulphuretted hydrogen when hydrochloric acid is added to it, and by its reactions on the metallic solutions already noticed. Its emanations blacken paper moistened with a solution of acetate of lead. Caustic potash causes the evolution of ammonia.

The complete saturation of the ammonia with sulphuretted hydrogen is known by sulphate of magnesia, as already mentioned.

Purity.—When badly prepared, bihydrosulphuret of ammonia sometimes deposits black flakes of sulphuret of iron. These must not be confounded with the black sulphuret of lead produced by the action of the bihydrosulphuret on the lead of the glass. They arise from a portion of the iron liquor being carried over into the ammoniacal solution along with the sulphuretted hydrogen, as already mentioned.

By exposure to the air, as by keeping in badly-stoppered bottles, or in bottles containing a small quantity of the liquid and a large quantity of air, the solution of the bihydrosulphuret of ammonia undergoes decomposition. It becomes yellow, ammonia is evolved, a deposit of sulphur takes place, and the pentasulphuret of ammonium (NH^4,S^5), or perhaps in some cases the heptasulphuret of ammonium, is formed. The solution now, when supersaturated with hydrochloric acid, yields an abundant white precipitate of sulphur. The bihydrosulphuret, when long kept, yields a red precipitate with a solution of acetate of lead; a yellow one with a solution of emetic tartar; and a white one with a solution of arsenious acid.

Composition.—Bihydrosulphate of ammonia has the following composition:—

	Ats.	*Eq.Wt.*	*P.Ct.*		*Ats.*	*Eq.Wt.*	*P.Ct.*		*Vols.*
HydrosulphuricAcid	2	34	66·66	Sulphuret of Hydrogen	1	17	33·33	Hydrosulph. Acid Gas	2
Ammonia	1	17	33·33	Sulphuret of Ammonium	1	34	66·66	Ammoniacal Gas	2
Bihydrosulphate of Ammonia	1	51	100·00	Sulph. of Hydrogen and Ammonium	1	51	100·00		4

Physiological Effects. *α. On Vegetables.*—The vapour of this compound is injurious to vegetation.

β. On Animals.—I am unacquainted with any experiments made with it on animals; but analogy leads us to believe that its action is that of a powerful poison, analogous to that of other alkaline sulphurets and of hydrosulphuric acid.

γ. On Man.—In *small* but *repeated doses* it acts powerfully on the secreting organs, the action of which it promotes, but at the same time modifies. Its principal influence is directed to the skin (on which it operates as a sudorific) and to the pulmonary mucous membrane. In *somewhat larger doses* it occasions nausea and giddiness. In *still larger doses* it causes nausea, vomiting, diminished frequency of pulse, giddiness, extreme languor, drowsiness, and sleep. *Excessive doses* would, of course, produce death, though I am unacquainted with any case of this kind.

In the gaseous state it acts, when inhaled, as a powerfully asphyxiating agent. Instances of its deleterious operation, in conjunction with hydrosulphuric acid, have occurred in France in workmen exposed to the vapours from the pits (cesspools) of the necessaries. The symptoms are—sudden weakness, insensibility, and death; or, where the vapours are less concentrated, there are sometimes delirium and convulsions.

USES.—In this country it has been principally employed in *diabetes mellitus*, with the view of reducing the morbid appetite and increased action of the stomach, as well as of the system in general.[1] It has also been used in old pulmonary catarrhs, and, by Brauw and Gruithuisen, in vesical catarrh.[2]

ADMINISTRATION.—It is given in doses of from four to six drops in some proper vehicle (distilled water is the best) three or four times a day. Dr. Rollo recommended that the dose should be increased so as to produce slight giddiness. It is, however, a dangerous medicine, and requires great caution in its use. On account of its speedy decomposition, it should be dropped from the bottle at the time of using it.

ANTIDOTES.—The antidotes for hydrosulphate of ammonia, as well as for hydrosulphuric acid, are chlorine and the chlorides of lime and soda (see *ante*, p. 161). In cases of asphyxia by the inhalation of the hydrosulphate, the treatment consists in placing the patient on his back in the open air, with his head somewhat elevated; applying cold affusion to the face and breast; producing artificial respiration of air (through which chlorine is diffused) by pressing down the ribs and forcing up the diaphragm, and then suddenly removing the pressure; using strong friction in the course of the vertebral column, chest, soles of the feet, &c., and injecting into the stomach stimulants, as a weak solution of chlorine (or of chloride of lime) or brandy, &c. In the event of hydrosulphuret of ammonia being by accident swallowed in poisonous doses, dilute solutions of chlorine, or of the chlorides of lime and soda, should be immediately given, and the contents of the stomach removed by the stomach-pump as soon as possible.

2. Boyle's Fuming Liquor of Sulphur.

HISTORY.—Beguin[3] described the method of preparing this compound, which he called *oil of sulphur* (*oleum sulphuris*). Boyle,[4] who also gives directions for its preparation, called it *volatile tincture of sulphur*, and says that it "may probably prove an excellent medicine." F. Hoffmann[5] refers to Beguin's work, and also gives a formula for its preparation. He calls it *tinctura sulphuris volatilis sive spiritus salis ammoniaci sulphureus, aurei coloris.* He also refers to it under the name of *spiritus sulphuris volatilis.*

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[1] Rollo, on *Diabetes Mellitus*, p. 28, 2d edit.

[2] Vogt, *Pharmacodynamik*.

[3] *Tyrocinium Chymicum*, p. 180, Wittebergæ, 1650. Also the English translation of this work, p. 65, Lond. 1669.

[4] *Experimental History of Colours*, part. iii. exp. xxxiv. (Boyle's *Works*, vol. ii. p. 59, Lond. 1754.)

[5] *Observationum Physic.-Chymic.* lib. ii. observ. xxxi. (*Opera omnia*, t. iv. p. 514, Genevæ, 1748.)

It is commonly called *Beguin's volatile spirit of sulphur* or *Boyle's fuming liquor* (*liquor fumans Boylii*), though I cannot find that either of these authors called it by these names. It is the *volatile liver of sulphur* (*hepar sulphuris volatile*) of some writers.

Its proper chemical name is at present doubtful.

PREPARATION.—It is obtained by submitting to distillation a mixture of sulphur, sal ammoniac, and lime. Beguin orders one pound of sulphur, half a pound of quicklime, and four ounces of sal ammoniac. Boyle directs five ounces of sulphur, five ounces of sal ammoniac, and six ounces of quicklime. Later writers order one part of sulphur, two of sal ammoniac, and two, three, or four parts of slacked lime. Some employ in addition three parts of water in the receiver; but no water is mentioned in the original formulæ of Beguin and Boyle.

Liebig says it may be procured by shaking the hydrosulphate of ammonia with sulphur as long as the latter is dissolved. The clear liquor is then to be poured off the excess of sulphur.

The composition of this liquor being doubtful, it is obvious that the explanation of the reactions which occur cannot be precise. At the commencement of the process ammonia is evolved. This arises from the mutual reaction of lime and sal ammoniac. $NH^3,HCl + CaO = NH^3 + CaCl + HO$. No ammonia is decomposed during the operation. The sulphur takes hydrogen from the hydrochloric acid, and, with ammonia, forms the fuming liquor. The residue in the retort after the operation is a mixture of chloride of calcium, sulphuret of calcium, and sulphate of lime. L. Gmelin gives the following equation illustrative of the changes: $4CaO + 3(NH^3,HCl) + 16S = 3CaCl + CaO,SO^3 + 3(NH^3,HS^5)$.

PROPERTIES.—An orange-yellow liquid, having an oily consistence. It fumes in the air and in oxygen gas, but not in hydrogen or nitrogen. This fuming property does not depend, as in the case of the strong mineral acids, on the attraction of atmospheric humidity, but on the oxidation of the volatile compound and the formation of hyposulphite of ammonia in the form of a fine dust.

Characteristics.—It is characterised by its fuming property, by its odour (that of sulphuretted hydrogen and ammonia), and by its colour. The deeper its yellow colour, the better is its quality reckoned. When decomposed by excess of hydrochloric acid, it gives out sulphuretted hydrogen gas and lets fall a white precipitate of sulphur (see *ante*, p. 453). It is entirely volatilized by heat.

COMPOSITION.—Its composition has not been very accurately ascertained. Berthollet[1] considered that it was a hydrosulphuret of ammonia with excess of ammonia, and Mr. Graham regards it as a protosulphuret of ammonium (NH^4,S).

Gay-Lussac,[2] however, considered it to be a compound of hydrosulphate of ammonia with several atoms of sulphur. L. Gmelin says that it is perhaps a watery mixture of hydrosulphate of ammonia and pentasulphuret of ammonium. Brande calls it persulphuret of ammonia.

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[1] *Ann. de Chimie*, t. xxv. p. 244.

[2] *Cours de Chimie*, t. ii. 20me Leçon, 1828.

EFFECTS.—Similar to those of bihydrosulphate of ammonia (see *ante*, p. 453).

USES.—Beguin says that it is very useful for wounds and ulcers. F. Hoffmann employed it in combination with rectified spirit of wine under the name of *liquor antipodagricus*. This consisted of one part of the fuming liquor and three parts of rectified spirit. He gave it in doses of thirty or forty drops as a powerful sudorific, and applied it, mixed with camphor, to the affected parts, and says that it relieved pain like a charm.

33. Ammoniæ Sulphas.—Sulphate of Ammonia.

Formula NH^3,SO^3,HO; or NH^4O,SO^3. *Equivalent Weight* 66.

Sulphate of the oxide of ammonium; Oxysulphion of ammonium; Glauber's secret sal ammoniac (*sal ammoniacum secretum Glauberi*).—This salt is found native, in the neighbourhood of volcanoes, under the name of *mascagnine*. It is a constituent of soot from coals. It is usually obtained by dissolving hydrated sesquicarbonate of ammonia in diluted sulphuric acid to saturation, and evaporating so that crystals may form as the solution cools. In an impure state it is procured by saturating the ammoniacal liquor of gas works or bone spirit with sulphuric acid; and the sulphate thus obtained is used in the preparation of sal ammoniac. Sulphate of ammonia, when crystallized ($NH^3,SO^3,2HO$), contains two equivalents of water; of one of which it may be deprived by heat. Anhydrous sulphate of ammonia does not appear to exist; for when anhydrous sulphuric acid and ammoniacal gas are combined, a compound is formed in which neither sulphuric acid nor ammonia are evident to the usual tests. Its composition is supposed to be NH^2,SO^2+HO; and it has been denominated *sulfamide*. Sulphate of ammonia was formerly employed as a stimulant, resolvent, and diuretic. Dose, ℈j. to ʒss.—It serves for the preparation of sal ammoniac and sesquicarbonate of ammonia (see *ante*, pp. 436 and 445).

The *spiritus cornu cervi rectificatus*, completely saturated with sulphuric acid, was ormerly employed in medicine under the name of *liquor anixii*.[1] The dose was 60 drops.

34. Ammoniæ Nitras.—Nitrate of Ammonia.

Formula NH^3,NO^5,HO; or NH^4,O,NO^5. *Equivalent Weight* 80.

Nitrate of the oxide of ammonium; Nitrum semivolatile; Nitrum flammans.—This salt is obtained by saturating diluted nitric acid with sesquicarbonate of ammonia, and evaporating so that crystals may form when the solution cools. If the solution be evaporated at a temperature below 100° F., large and beautiful six-sided prisms are obtained, terminated by six-sided pyramids (*prismatic nitrate of ammonia*). These crystals belong to the right prismatic system, and are isomorphous with nitrate of potash. They consist of one equivalent nitric acid 54, one equivalent ammonia 17, and one equivalent water 9. If the solution be boiled down, fibrous crystals are obtained (*fibrous nitrate of ammonia*). When dried at 300° F., nitrate of ammonia assumes the form of a compact white mass (*compact nitrate of ammonia*). In doses not exceeding a scruple, this salt acts as a diuretic; and, according to the experiments of Wibmer[2] made on himself, it reduces the frequency of the pulse and the animal heat, without affecting the head, chest, or stomach. It has been given in fevers and acute catarrhs, in doses of from one to two scruples. But it is rarely employed.

It is the source from whence *protoxide of nitrogen* is obtained (see p. 405). As it generates considerable cold while dissolving in water, it is sometimes used to form a freezing mixture. Lastly, it is occasionally employed to promote the incineration of organic substances.

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[1] Richter's *Ausfuhrliche Arzneimittellehre*, Bd. iv. p. 222.

[2] *Die Wirkung der Arzneimittel und Gifte*, Bd. i. S. 130, Munchen, 1831.

35. AMMONIÆ ACETAS.—ACETATE OF AMMONIA.

Formula $NH^3,C^4H^3O^3,HO$; or NH^4,O,AcO^3. *Equivalent Weight* 77.

History.—A solution of this salt appears to have been first described in 1732 by Boerhaave, who introduced it into the Materia Medica. It was subsequently employed by Minderer or Mindererus; and hence obtained one of its names, *spiritus* seu *liquor Mindereri*. It is also termed *aqua ammoniæ acetatis*.

Natural History.—Acetate of ammonia, or acetate of the oxide of ammonium, is, I believe, always an artificial compound.

Preparation.—The *London College* directs *liquor ammoniæ acetatis* to be prepared with Sesquicarbonate of Ammonia ℥ivss., or as much as may be sufficient, and Distilled Vinegar Oiv.; add the Sesquicarbonate of Ammonia to the Vinegar to saturation.

The *Edinburgh College* orders "Distilled Vinegar (from French Vinegar in preference) f℥xxiv.; Carbonate [Sesqui] of Ammonia ℥j.; mix them and dissolve the salt. If the solution has any bitterness, add by degrees a little distilled vinegar till that taste be removed. The density of the distilled vinegar should be 1·005, and that of Aqua Acetatis Ammoniæ 1·011."

The *Dublin College* directs "one part of Carbonate of Ammonia to be added gradually and with frequent agitation to as much distilled vinegar as may be requisite to saturate the ammonia—namely, about thirty parts. The saturation is to be determined by means of litmus."

In practice, diluted acetic acid is frequently substituted for distilled vinegar; and as the per centage strength of this acid, as found in commerce, is subject to considerable variation, so must be the strength of the solution of acetate of ammonia. To obviate this, it would have been better if the British Colleges had fixed absolutely the quantity of hydrated sesquicarbonate of ammonia which should be employed to yield a given number of fluidounces of the solution of acetate of ammonia. Apothecaries then would be at liberty to employ a stronger or a weaker acetic acid, without affecting the strength of the product.[1]

Every equivalent of hydrated sesquicarbonate of ammonia requires two equivalents of anhydrous acetic acid to form a neutral compound, while three equivalents of carbonic acid gas are set free. $2NH^3,3CO^2,2HO+2AcO^3=2(NH^3,AcO,HO)+3CO^2$.

Materials.		Composition.		Products.	
1 eq. Hydrated Sesquicarbonate of Ammonia ..	118	*3 eq. Carbonic Acid*	66	3 eq. Carbonic Acid ..	66
		2 eq. Water	18		
		2 eq. Ammonia	34		
2 eq. Acetic Acid........	102			2 eq. Acetate Ammonia	154
	220				220

Properties.—When pure this liquid is colourless. Any tint, therefore, which the solution of the shops may have, is referable to impurities in either the vinegar or the sesquicarbonate. Filtering it through powdered animal charcoal will usually remove any yellow or brown colour which it may have. If quite neutral, it will affect neither turmeric nor litmus paper. It is better, however, to have a sligkt excess of acid present than of sesquicarbonate, for if the latter predominate, the solution is much more irritant; and if employed as a collyrium, might produce inconvenient results.

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[1] For some remarks on the different strengths of this preparation in the different European pharmacopœias, see Mohr, in the *Berlinisches Jahrbuch für die Pharmacie*, Bd. xliii. S. 253, Berl. 1840.

Characteristics.—It is totally dissipated by heat. With nitrate of silver it yields crystals (*acetate of silver*) soluble in water. When concentrated it evolves vapours of acetic acid on the addition of strong sulphuric acid, and gives out ammonia if potash or lime be mixed with it. With sesquichloride of iron it yields a red liquor (*peracetate of iron*).

COMPOSITION.—By evaporating a saturated solution of acetate of ammonia under the exhausted receiver of the air-pump, and over sulphuric acid, crystals of the acetate are obtained. They are transparent oblique rhomboidal prisms, and consist, according to Dr. Thomson, of

	Atoms.	*Eq. Wt.*	*Per Cent.*
Acetic Acid	1	51	38·931
Ammonia	1	17	12·977
Water	7	63	48·091
Crystallized Acetate Ammonia	1	131	99·999

The quantity of dry or anhydrous acetate of ammonia contained in the solution kept in the shops, varies with the strength of the distilled vinegar. According to Mr. Phillips, 100 grs. of distilled vinegar contain 4·6 per cent. of acetic acid; and consequently 100 grains of liquor ammoniæ acetatis, prepared from such vinegar, would be composed as follows:—

Acetate of Ammonia (NH^3,AcO^3)	6·0407
Water	93·9593
Liquor Ammoniæ Acetatis, *Ph. L.*	100·000

IMPURITIES.—This solution ought neither to be discoloured by the addition of hydrosulphuric acid, nor to throw down any precipitate by nitrate of silver or chloride of barium. These substances, therefore, may be employed to detect, respectively, metallic matter, hydrochloric acid or a chloride, and sulphuric acid. Pure acetate of ammonia occasions no precipitate with diacetate or acetate of lead; but the liquor ammoniæ acetatis of the shops usually does, owing to the presence of carbonic acid. It should be quite neutral to test paper.

PHYSIOLOGICAL EFFECTS.—In small doses this solution is regarded as a refrigerant: in large doses, diaphoretic, diuretic, and perhaps resolvent. These effects, however, are not very obvious. Wibmer[1] took it in moderate doses, yet did not observe any diaphoretic, diuretic, or purgative effects from it; but he experienced headache and disturbed digestion. Dr. Cullen[2] says, "I have known four ounces of it taken at once, and soon after four ounces more, without any sensible effect." The local operation of this solution is that of a mild stimulant.

USES. *a. Internal.*—It is employed in febrile and inflammatory diseases, and forms a constituent of the ordinary saline draught. It is given in conjunction with nitrate of potash, or tartar emetic, and sometimes with camphor and opium. When administered as a diaphoretic, its operation should be promoted by the use of tepid diluents and external warmth. Its diuretic effect is assisted by keeping the skin cool, and conjoining the spirit of nitric ether.

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[1] *Die Wirkung*, &c.

[2] *Materia Medica.*

β. External.—Diluted with water it is sometimes employed as a discutient wash to inflamed and bruised parts. Mixed with six or seven times its volume of rose-water, to which a drachm or two of tincture of opium may sometimes be added, it is employed as a collyrium in chronic ophthalmia.

ADMINISTRATION.—It is given in doses of half a fluid ounce to two or three ounces every five or six hours.

36. Ammoniæ Citras.—Citrate of Ammonia.

Formula $3NH^3,C^{12}H^5O^{11},3HO$; or $3NH^4O,\overline{Ci}$. *Equivalent Weight* 243.

Neutral citrate of the oxide of ammonium.—A solution of this salt is obtained by saturating lemon or lime juice, or a solution of citric acid, with sesquicarbonate of ammonia. 201 grains of the ordinary commercial crystals of citric acid saturate 177 grains of hydrated sesquicarbonate of ammonia. But this neutral citrate cannot be obtained in the solid state; for by evaporation a portion of ammonia escapes, and an acid salt is produced, composed of $2NH^3,C^{12}H^5O^{11},2HO$; or $2NH^4O,\overline{Ci}$. Brande states that a crystallizable salt, $=NH^4O,2HO,\overline{Ci}$, may also be obtained. Liquid citrate of ammonia is employed either in the still or effervescent form as a cooling saline diaphoretic in febrile disorders.

37. Ammoniæ Tartras.—Tartrate of Ammonia.

Formula $2NH^3,C^8H^4O^{10},2HO$; or $2NH^4O,\overline{T}$. *Equivalent Weight* 184.

Neutral tartrate of the oxide of ammonium.—A solution of this salt is prepared by saturating 150 grs. of crystallized tartaric acid with 118 grs. of the hydrated sesquicarbonate of ammonia. It may be obtained in the form of prismatic crystals, $2NH^3,\overline{T},4HO$; or $2NH^4O,\overline{T},2HO$. The effects and uses of tartrate of ammonia resemble those of the citrate. It is employed either in the effervescent or still form.

If the tartaric acid be in excess, a difficultly soluble crystalline precipitate of *bitartrate of ammonia*, $NH^3,\overline{T},2HO$, or $NH^4O,\overline{T},HO$, is obtained.

38. Ammoniæ Oxalas.—Oxalate of Ammonia.

Formula NH^3,C^2O^3,HO; or $NH^4O,\overline{O}$. *Equivalent Weight* 62.

Oxalate of the oxide of ammonium.—In the Edinburgh Pharmacopœia this salt is directed to be prepared as follows: Take Oxalic Acid, ℥iv.; Carbonate [Sesquicarbonate] of Ammonia, ℥viij.; Distilled Water, Oiv. Dissolve the carbonate in the water, add gradually the acid, boil, and concentrate sufficiently for crystals to form on cooling. The prismatic crystals thus formed consist of $NH^3,C^2O^3,2HO$; or NH^4O,C^2O^3,HO. By heat they suffer decomposition, and yield *oxamide (oxalamide)*, composed of HN^2,C^2O^2. Oxalate of ammonia was introduced into the Edinburgh Pharmacopœia as a test for calcareous solutions, with which it produces a white precipitate *(oxalate of lime)*, which is readily soluble in nitric acid, but is only moderately soluble in hydrochloric acid. It does not occasion any precipitate in the solutions of the magnesian salts; hence it is a valuable agent for separating lime from magnesia. According to the experiments of Drs. Christison and Coindet,[1] it is but little inferior in the energy of its operation on the body to oxalic acid. Ninety grains, which contain thirty-six grains of oxalic acid, killed a strong cat in nine minutes. The symptoms were tetanus and coma.

39. Aër.—Atmospheric Air.

Although atmospheric air is not, strictly speaking, an article of the Materia Medica, yet its relations to life, health, and disease, are so manifold and important, and its agencies in pharmacy and materia medica so numerous, essential, and influential, that a work, like the present, in which constant reference is made to atmospheric air, can scarcely be considered complete without some notice of this agent.

1. *Definition.*—The atmosphere is that transparent elastic fluid which surrounds and encloses the earth with which it revolves.

2. *Extent.*—There is reason to believe that it is of finite extent,[2] and that it reaches only to about forty-five miles from the surface of the earth.

3. *Physical properties.*—Like other aëriform bodies, air is elastic, and is, therefore, compressible and expansible. When pure, it is odourless and tasteless. At 60° F. and 30 in. bar., 100 cubic inches of pure dry atmospheric air weigh about 31 grs. troy.[3] Its density at the same temperature and pressure is assumed as the standard of comparison for the densities of other gaseous or aëriform bodies; and its sp. gr., therefore, is said to be 1·000.

As air has weight it must necessarily exert pressure, the amount of which is liable to variation. The mean pressure is assumed in England to be equal to a column of mercury of 30 English inches; in France to one of 76 centimetres, or 760 millimetres (=29·92 English inches); and in Germany to one of 28 Paris inches (=29·83 English inches). As mercury at 60° F. is about 13·568 times as heavy as water, it follows that a column of 30 inches of mercury is equal to one of water of $30 \times 13{\cdot}568 = 407$ inches (=33·92 feet); and as a cubic inch of water at 60° weighs about 252·5 grs., it follows that the mean pressure of the air on each square inch of surface is equal to $252{\cdot}5 \times 407 = 14{\cdot}68$lbs. avoirdupois (usually assumed to be 15lbs.)

The density and temperature of the atmosphere diminish with its elevation; but no constant relation is found to exist between altitude and either density or temperature. In a general way, however, it may be stated that for every 1000 feet of elevation the mercury falls one inch; and for every 100 yards of ascent the temperature falls 1° F.

4. *Composition.*—Of the constituents of the atmosphere some are constant, others accidental.

The *constant* components are oxygen, nitrogen, aqueous vapour, and carbonic acid. These gaseous or aëriform bodies are in a state of mixture, not of chemical combination. The relative proportion of oxygen and nitrogen to each other is extremely uniform, and is scarcely, if at all, influenced by season, wind, weather, country, altitude of the air, or even the salubrity of it. From the recent experiments of Dumas and Boussingault, Brunner and others, we may assume the composition of pure dry air to be as follows[4]:—

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[1] *Edinburgh Medical and Surgical Journal*, vol. xix. p. 190.

[2] Wollaston, *Phil. Trans.* for 1822.

[3] The most accurate recent experiments on the weight of atmospheric air are those of Prout (*Report of the First and Second Meetings of the British Association*, p. 566, 1833) and Regnault (*Ann. de Chim. et de Phys.* 3me sér. t. xiv. p. 211, 1845). The following are the results of their observations:—

Cub. In.	*Inches.*	*At 32° F.*	*At 60° F.*	*Authority.*
100 Air dry, and deprived of carbonic acid..	Bar. 30 ..	32·7958 grs. ..	31·0117 grs. ..	PROUT.
100 " " " " "	Bar. 29·92 ..	32·7046 grs. ..	30·9407 grs. ..	REGNAULT.

[4] In 1841, Dumas and Boussingault (*Ann. Chim. Phys.* t. lxxviii.) analysed the air of the Jardin des Plantes, at Paris, and on the same day Brunner examined that of Bern, and Martins and

	By measure.		*By weight.*
Oxygen	20·8	....	23
Nitrogen	79·2	....	77
Air dry, and deprived of carbonic acid......	100·0	....	100

The proportion of carbonic acid and aqueous vapour is inconstant. Perhaps as an average we may assume that land air contains $\frac{1}{2000}$th of its volume of carbonic acid gas. The average proportion of aqueous vapour is more difficult to estimate, as the quantity is constantly fluctuating. It is more abundant with south and westerly winds than with north and easterly winds, and is greater in summer and hot weather than in winter and cold weather. The following table was drawn up by the late Dr. Henry;[1] it represents the supposed composition of the air and the pressure exerted by each ingredient in supporting the mercury of the barometer; and although possibly not quite accurate, is a close approximation to the truth:—

	By measure.		*By weight.*		*Pressure in inches of mercury.*
Nitrogen	77·5	....	75·55	....	23·36
Oxygen	21·0	....	23·32	....	6·18
Aqueous vapour	1·42	....	1·03	....	0·44
Carbonic acid	0·08	....	0·10	....	0·02
	100·00		100·00		30 00

The *accidental* constituents of the atmosphere may be regarded as adventitious or extraneous. Some of them are inorganic, others organic.

The inorganic constituents are derived from various sources. Some of them are products of electrical operations going on in the atmosphere; some are gases or vapours derived from particular localities of the earth or from operations on the surface of the earth; others are finely-divided solid bodies raised by the wind from the earth's surface, or volcanic dust projected into the atmosphere and suspended in the air. Many of them are detectable in the rain water which falls after long-continued drought, and have, therefore, been before alluded to (see *ante*, p. 289). Ammonia, probably in the form of carbonate, may be detected in rain and snow water. It is derived from the decomposition of animal and vegetable nitrogenous principles. It is an important constituent of the atmosphere, on account of its being a source of the nitrogenous principles of plants. It exists in such minute proportion as to be inappreciable in the small amount of air usually submitted to analysis; but it may be detected by adding hydrochloric acid to the first portions of rain which falls after long-continued dry weather and evaporating, by which sal ammoniac is obtained. Traces of sulphuretted hydrogen are indicated by the tarnish of silver. Sulphurous and sulphuric acids are found in the air of London and

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Bravais that of the Faulhorn (about 8800 feet above the level of the sea). The results were as follows :—

1841.	*Millimetres.*	*Temp.*	*Wind.*	*Weather.*	*Per centage of oxygen.* Paris.	Bern.	Faulhorn.
April 27	759·5 ...	73°·4 F. ...	S ...	Fine ...	22·92 ...		...
April 28	758·3 ...	77° ...	SE ...	Fine ...	23·06 ...		...
April 29	757·6 ...	80°·6 ...	NE ...	Fine ...	23·03 ...		...
May 29	757·9 ...	63°·32 ...	N ...	Rain ...	23·01 ...		...
July 20	733·9 ...	66°·2 ...	S ...	Rain ...	23·00 ...	23·00 ...	22·96
July 21	752·0 ...	58°·46 ...	SW ...	Fine ...	23·00 ...	22·89 ...	23·09
July 24	758·2 ...	64°·04 ...	NNW ...	Cloudy ...	23·08 ...	22·97 ...	22·91
Aug. 7	...	...	...	...	...	...	22·97
Sept. 20	758·9 ...	72·°68 ...	N ...	Fine ...	23·07 ...		...
Sept. 22	751·2 ...	69°·8 ...	SSW ...	Cloudy ...	22·89 ...		...

Mean quantity of oxygen in 100 parts by wegiht of dry air deprived of carbonic acid...... } 23·07

[1] *Elements of Experimental Chemistry*, vol. i. p. 298, 1826.

other places where coal is consumed as fuel. Traces of sulphate of ammonia are also found. The small stellated spots sometimes seen on dirty windows consist of this salt (Brande). Hydrochloric acid or common salt is found in the vicinity of the sea. Nitric acid, and various alkaline, earthy, and metallic salts, have been detected in rain water (see *ante*, p. 289), and have been derived from the atmosphere. To these must be added finely-divided carbonaceous matter, which constitutes the dark colour of smoke from coal fires, and which is deposited under the popular name of "blacks."

Dr. Prout[1] has hinted at the possible diffusion of a compound of selenium, or of some active ingredient like this, in the atmosphere as a cause of epidemic catarrh. In proof of the diffusion of some heavy matter through the air on the occasion of some epidemics, he states that on the 9th of February, 1832, the wind, which had previously been west, veered round to the east, the weight of the air suddenly appeared to rise above the usual standard, and at this time the first cases of epidemic cholera were reported in London; and he infers that the cholera was owing to the matter which thus produced the additional weight of the air.[2]

Organic matters of various kinds—some organised, others not—exist in the atmosphere. Nitrate of silver is employed as a test of their presence in rain and snow water (see *ante*, p. 280); but there is no reason for assuming with Zimmermann (see *ante*, p. 289) that the organic matter of rain water, called by him *pyrrhin*, is of a peculiar kind. The various odorous emanations of animals and plants are of an organic nature. I have already had occasion to allude to miasma or malaria (see *ante*, p. 69), the chemical nature of which is at present unknown, as well as to other dangerous emanations (see *ante*, p. 162). Boussingault[3] detected an organic carbonaceous matter in the air of a marshy meadow, and found 0·0001 of hydrogen (he thinks as light carburetted hydrogen, or marsh gas, CH^2) in the air of Paris. Mr. Graham[4] contends that contagious matters are not volatile or truly vaporous, but "are highly organised particles of fixed matter, which may find its way into the atmosphere notwithstanding, like the pollen of flowers, and remain for a time suspended in it."

Minute microscopic organisms, both vegetable and animal, doubtless exist in the atmosphere; but their presence has, in many instances, been assumed without evidence, either for the purpose of accounting for the development of infusorial animals and cryptogamic plants, and of thereby obviating the necessity of admitting their spontaneous generation,—or for the purpose of accounting for the propagation of infectious diseases. But the whole of this subject is enveloped in deep obscurity, and is, I am afraid, likely to remain so.

5. *Effects and uses.*—I must refer my readers to works on physiology for an account of the agency of the atmosphere in the animal and vegetable kingdoms. It will be sufficient, therefore, to observe that, with reference to the atmosphere, animals and plants are engaged in antagonistic operations:

Vegetables	*Animals*
Decompose carbonic acid.	*Produce* carbonic acid.
" water.	" water.
" ammonia.	" ammonia.
Evolve oxygen.	*Absorb* oxygen.

It is obvious, from this table, that vegetables purify the atmosphere, while animals deteriorate it.

I have already (see *ante*, pp. 68-71) noticed some of the circumstances which render the atmosphere of certain localities insalubrious.

The dangerous and, in many cases, fatal effects of the entrance of air into the veins[5] do not require consideration in a work on Materia Medica.

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[1] *Bridgewater Treatise* (*Chemistry and Meteorology*), p. 350.

[2] *Ibid.*; also *Report of the First and Second Meetings of the British Association*, p. 566, 1833.

[3] *Ann. Chim. et Phys.* lvii. 1834.

[4] *Elements of Chemistry*, 2d edit. p. 336.

[5] On this subject consult Dr. M'Cormack's *Inaugural Dissertation on the Presence of Air in the Organs of Circulation*, Edinb. 1837. Also a review of this work, as well as of the papers of Bouillaud, Amussat, and Velpeau, on the same subject, in Dr. Forbes's *British and Foreign Medical Review*, vol. vi. p. 456; likewise Chelius's *System of Surgery*, by South, vol. ii. p. 856.—The subject has recently acquired additional interest from the death of a patient, caused by air entering a vein, divided whilst inserting a seton in the neck (*Lond. Med. Gaz.* April 7, 1848, p. 608).

The important agency of the atmosphere in pharmaceutical operations is well known. By its aid artificial heat and light are obtained. It is an exhaustless source of oxygen in numerous operations (as of calcination, roasting, acetification, &c.) It is the ultimate source from whence nitric acid is produced, for nitrification is effected by the oxidation of ammonia. To it we are indebted for the purest form of natural water (see *ante*, p. 289).

Most of the deteriorations which time effects in medicinal agents are due to the destructive agency of the atmosphere; mainly to the influence of oxygen and aqueous vapour, and in part, also, to the presence of other bodies (see *ante*, p. 163).

6. *Purification and disinfection of the atmosphere.*—The purification of the atmosphere is naturally effected in two ways—by the chemical changes which the air effects on the various substances thrown into it, and by the agency of the vegetable kingdom already alluded to. "The atmosphere," says Mr. Graham, "contains within itself the means of its own purification, and slowly, but certainly, converts all organic substances exposed to it into simpler forms of matter, such as water, carbonic acid, nitric acid, and ammonia."

For the purpose of destroying putrescent effluvia, organic fetors, and miasmata, the agents called disinfectants or de-odorizers are employed. I have already had occasion to refer to the disinfecting powers of heat and of the class of chemical agents to which the denomination of *disinfectants* is usually applied (see *ante*, p. 162). Of the gaseous disinfectants Professor Graham thinks "that sulphurous acid gas (obtained by burning sulphur) is preferable, on speculative grounds, to chlorine. No agent checks more effectually the first development of animal or vegetable life. This it does by preventing oxidation. In the same manner it renders impossible the first step in putrefactive decomposition and fermentation. All animal odours and emanations are most immediately and effectively destroyed by it. The fetid odour from the boiling solution of cochineal (for instance), which is so persistent in dye-houses, is most completely removed by the admission of sulphurous acid vapour (T. Graham)."

ORDER XI. COMPOUNDS OF POTASSIUM.

40. Potassium.—Potassium.

Symbol K. *Equivalent Weight* 39.

Kalium; Basis of Potash.—Discovered by Davy on the 6th October, 1807. Procured for commercial purposes by decomposing potash by carbon. It is a silvery-white metal of great lustre. Its sp. gr. is 0·86507. Its consistency is that of wax. Its vapour is green. It rapidly attracts oxygen from the air and from moisture, and takes fire when thrown on water. It is usually preserved in Persian naphtha. Flat discs of it may be conveniently prepared by pressing a globule of the metal between two plates of glass, or between the fingers covered with naphtha. Potassium has been now and then employed as a cautery or moxa. Graefe[1] used it in four cases of gonalgia (pain in the knee), in two of which it proved successful; and Chevallier[2] (at the suggestion of Dumeril) proposed its use as a substitute for the actual cautery. Graefe placed it close to the skin, and set fire to it by a few drops of water. The surrounding parts were protected by a piece of pasteboard having a circular aperture, through which the potassium was applied. To circumscribe the effect a little more carefully, as well as to protect the operator from the sputtering of the burning metal, he subsequently employed a hollow brass cylinder, of about an inch in length and an inch in diameter, with a handle a foot long. The cylinder was introduced into the aperture of the pasteboard, and the potassium placed within it. When the combustion was over, the cylinder was removed, and the cauterised spot cleaned with lint. The skin confined within the cylinder was converted into a brownish-yellow eschar. Graefe thinks this mode of cauterization useful in poisoned wounds, as the bites of rabid animals.

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[1] Dierbach's *Die neuesten Entdeckungen in der Materia Medica*, 1er Bd. p. 484, 1837.

[2] *Journ. de Chimie Médicale*, Feb. 1845, p. 90.

41. Potassa.—Potash.

Formula KO. *Equivalent Weight* 47.

SYNONYMES.—*Protoxide of Potassium; Kali; Vegetable Alkali.*

HISTORY.—Caustic alkaline solutions were probably known to the Greeks and Romans. We learn from Pliny[1] that soap was made in his time from tallow and wood-ashes; and we may therefore conclude that some method was known of depriving the alkaline carbonate of its carbonic acid. Paulus Ægineta[2] describes the method of making a caustic lixivium, as does, also, Geber.[3] Black, however, in the year 1756, first distinguished chemically the caustic alkalies from their carbonates.

NATURAL HISTORY.—Potash in combination with acids is found in both kingdoms of nature.

α. IN THE INORGANISED KINGDOM.—Potash is found, in the mineral kingdom, in combination with sulphuric, nitric, silicic, and perhaps carbonic acids. As an ingredient of rocks, it is more abundant than soda.

β. IN THE ORGANISED KINGDOM.—In organised beings, potash is met with in combination with phosphoric, sulphuric, nitric, carbonic, and various organic acids. It occurs more abundantly in vegetables than in animals.

PREPARATION.—Anhydrous potash is obtained by the oxidation of potassium, by the partial deoxidation of peroxide of potassium, or by heating one atom of hydrate of potash with one of potassium. $K + KO,HO = 2KO + H$.

PROPERTIES.—It is a hard, grey, brittle substance, fusible at a bright red heat, sp. gr. about 2·656, odourless, extremely caustic and alkaline.

Characteristics.—A solution of potash or of a neutral potash salt is recognised by the following characters:—Solutions of the hydrosulphurets, ferrocyanides, and carbonates, produce no precipitate with it. Solutions of tartaric (in excess), perchloric, and carbazotic acids, occasion crystalline precipitates of the bitartrate, perchlorate, and carbazotate of potash respectively. A solution of bichloride of platinum throws down a yellow precipitate ($KCl,PtCl^2$). Lastly, the potash salts communicate a violet tinge to the flame of alcohol.

Free potash is distinguished from its salts by its communicating a green colour to the infusion of red cabbage or syrup of violets; by its reddening turmeric, and restoring the blue colour of litmus reddened by an acid; by its not effervescing on the addition of an acid; by its soapy feel; by its solubility in alcohol; and by its dissolving alumina. Anhydrous potash is more difficultly fusible and harder, and is a worse conductor of electricity, than the hydrate of potash.

COMPOSITION.—Pure anhydrous potash has the following composition:—

	Atoms.	*Eq. Wt.*	*Per Cent.*	*Berzelius.*	*Davy.*	*Gay Lussac and Thenard.*
Potassium	1	39	82·98	83·0484	85	83·371
Oxygen	1	8	17·02	16·9516	15	16·629
Potash	1	47	100·00	100·0000	100	100·000

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[1] *Hist. Nat.* lib. xxviii. cap. 51.

[2] Adams's translation of Paulus Ægineta, vol. ii. p. 264, and vol. iii. p. 185.

[3] *Invention of Verity*, ch. iv.

PHYSIOLOGICAL EFFECTS.—In considering the effects of potash, we have to notice its effects as a constituent of other substances, and also its effects when taken in the free state.

1. *Effects of potash as a constituent of other substances.*—Potash and its basis potassium are essential constituents of the human body. They preponderate in the juice of flesh and in the milk. It is obvious, therefore, that they are necessary ingredients of our food; and that, if they be deficient or absent, nutrition will be imperfect. It follows, also, that for the cure of disorders resulting from the use of food deficient in potash, the administration of this alkali is requisite.

Dr. Garrod[1] is of opinion that scurvy is produced by a deficiency of potash in the food; and that, by the addition of potash (in the form of some salt) to their food, scorbutic patients will recover without the use of either succulent vegetables or milk. He gives the following table of the amount of potash in several articles of food:—

TABLE *shewing the quantity of potash* (KO) *contained in one ounce avoirdupois* (=7000 grs.) *of the following alimentary substances.*

	Grains of potash.		*Grains of potash.*
Baker's best bread (City)	0·259	Salt beef boiled (slightly salted)	0·572
Best bread (West-end)	0·257	Boiled mutton	0·637
Home-made bread, probably containing potato flour	0·262	Dutch cheese	0·230
Best white flour	0·100	Boiled potatoe (large size)	1·875
Bran	0·609	Raw potatoe (small)	1·310
Rice	0·005	Boiled potatoe, without peel and well done, water containing much potash	0·529
Rice	0·011	Onion (small)	0·333
Oatmeal	0·054	London milk (1 fluid ounce)	0·309
Split peas	0·529	Orange (not ripe), including septa	0·675
Raw beef	0·599	Lime-juice (1 fluid ounce)	0·852
Salt beef raw	0·394	Lemon-juice (1 fluid ounce)	0·846

The best antiscorbutics, therefore, according to Dr. Garrod, are those which contain the largest amount of potash. These are potatoes (especially when unpeeled and not too much boiled), fruits (as oranges, lemons, limes, grapes, and gooseberries), milk, fresh meat, fresh vegetables (as cabbages, turnips, onions, garlic, and leaks), pickles, spruce beer, wort, malt liquors, and wines (especially the lighter kinds). From Dr. Garrod's table it would appear that rice, oatmeal, and even wheat-flour, belong to what might be called scorbutic foods. Moreover it would appear that wheat-bread is superior to wheat-flour in the amount of potash which it contains,—a circumstance which probably depends on the use of potatoes and alum in its manufacture.

According to Dr. Garrod, when the weekly amount of potash in the food amounted to 186 grs., the inmates of the Crediton Union Workhouse remained healthy; but when, by the substitution of rice for potatoes, the weekly consumption of potash was reduced to 51 grains, scurvy broke out. Dr. Garrod treated scurvy by giving daily from twelve to twenty grains of a salt of potash (bitartrate, acetate, carbonate, or phosphate) mixed with syrup and water.

Dr. Garrod's views are interesting on account of their novelty, ingenuity, and importance. But it must be borne in mind that his statements or conclusions, on which this theory of scurvy mainly rests, require confirmation;

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[1] *Monthly Journal of Medical Science,* Jan. 1848.

and that, should many of them be eventually established, it by no means follows that a deficiency of potash is the sole cause of scurvy. Indeed, there is reason to believe that scurvy sometimes exists when there has been no want of this alkali in the food. It prevailed, for example, to a frightful extent, in 1822, in his Majesty's ship Leander, despite the plentiful administration of large quantities of lemon juice,[1] which, according to Dr. Garrod, is rich in potash and is highly antiscorbutic. Salted meats in the preparation of which nitre has been used ought to be antiscorbutic.

In milk the salts of potash greatly preponderate over those of soda; and hence a plentiful supply of potash is one of the conditions necessary for the secretion of this fluid. In this sense potash may be said to belong to the *galactophora*, or milk-promoters. It is remarkable, however, that sulphate of potash has been reputed as a *galactifuge*, or milk-represser.

The beneficial effects of the *grape-cure* (*cure de raisins*) in the treatment of inflammatory dyspepsia and other maladies are probably in part due to the influence of the potash taken into the system.

Of the ill effects produced by the long-continued use of large quantities of substances abounding in potash we have no positive evidence.

2. *Effects of free potash*.—By free potash is meant potash uncombined with acids. It includes, therefore, anhydrous potash, hydrate of potash, and solutions of caustic potash. Potash in the anhydrous state is not, however, employed in medicine; and our remarks, therefore, must apply to the two latter preparations.

α. *On Vegetables*.—Caustic potash promptly destroys the parts of living plants with which it is placed in contact, and even in the dilute state kills haricots (*Phaseolus vulgaris*) in a few hours.[2]

β. *On Animals generally*.—It acts on animals generally as an energetic caustic poison. Orfila[3] found that, injected into the jugular vein of a dog, it coagulated the blood and caused speedy death. It is, however, remarkable that, when mixed with the blood out of the body, it not only does not coagulate it, but actually prevents its spontaneous coagulation.

γ. *On Man*.—In its local and remote action, potash partakes of the properties of the alkalies generally, and which have been already noticed (see *ante*, pp. 94 and 176). Its local action is exceedingly energetic. It neutralizes any free acid in the part to which it is applied; decomposes whatever ammoniacal salts may be present, causing the evolution of ammoniacal gas; and dissolves fibrin, albumen, mucus, gelatine, &c. Hence, rubbed between the fingers, it corrodes and dissolves the epidermis, and thereby gives rise to a soapy feel. These phenomena are to a certain extent comparable to those of saponification. As, then, potash, like the other alkalies, forms soluble compounds with substances which enter largely into the composition of the organised tissues, we can readily explain Orfila's observation, that alkalies are, of all corrosive poisons, those which most frequently perforate the stomach; for the intestinal mucus readily dissolves in alkalies, whereas it is coagulated by acids; so that the former are much more quickly brought in contact with the living tissues. These resist, for a certain time, the chemical influence of the caustics; but the affinities being powerful, the vital properties soon cease to offer opposition—the part dies (*biolysis*) and the tissues are speedily dissolved (*morpholysis*, see *ante*,

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[1] See my *Treatise on Food and Diet*, p. 358.

[2] Marcet, in De Candolle, *Phys. Végét.*

[3] *Toxicol. Génér.*

p. 95). Hence, if a large quantity of potash be swallowed, the most violent symptoms are observed, though they are of the same general kind as when the mineral acids have been taken (see p. 358). Like other corrosives, it powerfully depresses the heart's action (see p. 114).

When liquor potassæ is taken in small doses, and properly diluted, it destroys the acidity of the contents of the stomach, which the recent investigations of physiologists have shown to be essential to the digestion of albuminous substances. Hence the continual use of it is liable to prove injurious, by altering the chemical properties of the healthy ventricular secretion. Like other alkalies, it may perhaps aid the digestion and absorption of fatty substances (see *ante*, p. 177).

In somewhat larger doses, it acts as a slight irritant, augments the secretions of the alimentary canal, becomes absorbed, and communicates an alkaline quality to the urine (see *ante*, p. 177). Moreover, the modification thus produced in the quality of the renal secretion is accompanied by an increase in the quantity (see *ante*, p. 250).

By continued use, potash acts as a liquefacient, resolvent, and impoverisher of the blood (see *ante*, pp. 175 and 177).

Uses.—Caustic potash is employed for various purposes in medicine, the principal of which are the following:—

α. *As an escharotic* (see *ante*, p. 157).—Potassa fusa is sometimes used as a caustic, though its employment is not free from objection; for its great deliquescence occasions some difficulty in localizing its action. It may be employed for the production of an issue, and is used thus:—Apply to the part one or two layers of adhesive plaster, in the middle of which is an aperture of the exact size of the intended issue. Then moisten the *potassa fusa*, or the *potassa cum calce*, and rub it on the part until discolouration is observed. Wash, and apply a linseed-meal poultice; and when the eschar is detached, insert the pea. Issues, however, are speedily and more conveniently made by the lancet than by caustic. In bites by poisonous animals—as venomous serpents, mad dogs, &c., this escharotic may be used with advantage. Mr. Whateley[1] recommends the *potassa fusa* as the agent for arming caustic bougies to be applied in strictures of the urethra; but the practice appears so dangerous (particularly on account of the deliquescence and violent action of the caustic), that I believe it is now rarely, if ever, resorted to. There are many other cases in which this substance is employed as a caustic: for example, to destroy warts and fungoid growths of various kinds, and to open abscesses; but for the latter purpose the lancet is to be preferred.

β. As an *antacid* we resort to the *liquor potassæ* in various affections of the digestive organs which are attended with an inordinate acidity of stomach, known by acid eructations, cardialgia, and other dyspeptic symptoms. It must, however, be evident, that the neutralization of acid is merely palliative. But the continued employment of alkalies frequently diminishes, temporarily, the tendency to acid secretion. Commonly it is found that the cases calling for their employment are those benefited by tonics, and hence they are usually given in some tonic infusion; as the infusion of calumba, or of gentian, or of quassia. Their beneficial effects are frequently manifested in those forms of dyspepsia which result from the use of spirituous liquors.

γ. *To render the urine alkaline, or to diminish its acidity.*—In preternatural acidity of urine, especially in lithic acid deposits, potash is used as an alterative lithic (see *ante*, p. 258). But in general I believe the carbonate or vegetable salts of the alkalies are preferable, in these cases, to the caustic alkalies; as they are equally effective in rendering the urine alkaline, and are less injurious to the digestive organs. The alkalies act as solvents for lithic acid, as the alkaline lithates are more soluble than the free acid. They also probably prevent the formation of this acid, or neutralize the free acid in the urine, which is the immediate cause of the precipitation of the lithic acid. As a lithonlytic, caustic potash has been exhibited both by the mouth and by injection into the bladder (see *ante*, pp. 258 and 261). In all these cases care should be taken to avoid employing it when there is any tendency to the deposition of the phosphates. In the treatment of the lithic acid diathesis, it is to be remembered that the use of alkalies is, to a certain extent, a palliative mode of treatment, and that, to be successful, it should be conjoined with other means of cure.

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[1] *An Improved Method of Treating Strictures of the Urethra*, Lond. 1804.

δ. *As an antiplastic, liquefacient, and resolvent* (see p. 178).—For these purposes the alkaline carbonates are to be preferred to the caustic alkalies.

ε. As a *resolvent* and *sorbefacient*, induration and enlargement of the lymphatic and secreting glands, for example, in bronchocele, mammary tumors, affections of the testicle, diseases of the mesenteric glands, induration of the liver and salivary glands, &c., liquor potassæ has been used with benefit. I have seen it remarkably beneficial in excessive enlargement of the lenticular or glandular papillæ at the base of the tongue.

ζ. In *syphilis* and *scrofula* liquor potassæ has been employed with advantage. Some of the most obstinate and troublesome forms of the venereal disease frequently occur in scrofulous subjects, in whom mercury is not only useless, but absolutely prejudicial. In cases of this kind the liquor potassæ, taken in the compound decoction of sarsaparilla, is often very serviceable. In scrofula, the long-continued use of the caustic alkalies (as potash and ammonia) has been attended with remarkably beneficial effects. Caustic potash was most extensively employed by Mr. Brandish,[1] during many years, in the treatment of scrofula and other chronic diseases, and, according to his report, with singular success. It is, however, more successful in young than in old persons,—and in those of fair and light complexion than in the dark and the swarthy.

η. Liquor potassæ is employed as a *diuretic in dropsy*, especially when this disease arises from glandular enlargements, or other causes likely to be relieved by alkaline remedies.

ϑ. In *irritable conditions of the urinary organs* a combination of liquor potassæ and opium will be frequently found most beneficial, notwithstanding that alkalies are classed among the incompatibles of the latter substance. This combination I have also frequently found useful in allaying *uterine irritation*.

ι. In *chronic skin diseases*, especially psoriasis, pityriasis, and acne, the long-continued employment of liquor potassæ is sometimes attended with relief. In acne punctata, a weak alkaline solution (as ℥ss. of liquor potassæ in a pint of soft water) is often employed, with the aid of a coarse towel and friction, to remove the thick sebaceous secretion from the follicles.

κ. In *rheumatism* and *gout*, especially when attended with lithic acid deposits in the urine, liquor potassæ may be advantageously administered.

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[1] *Observations on the Use of Caustic Alkali in Scrofula and other Chronic Diseases*, Lond. 1811.

λ. In *chronic bronchitis* with a very rough and viscid secretion, liquor potassæ is used to diminish the viscidity of the mucus.

μ. In *amenorrhœa*, potash has been employed as an emmenagogue.

ν. Sometimes a very dilute solution of potash has been used as a *stimulating wash* to ulcers.

Antidotes.—(See *ante*, p. 161.)

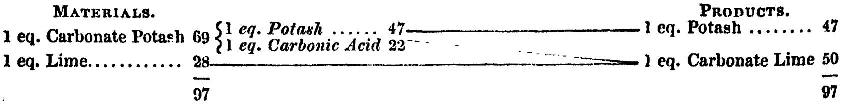
1. LIQUOR POTASSÆ, L.; *Potassæ Aqua*, E.; *Potassæ Causticæ Aqua*, D.; *Solution of Potash; Water of Caustic Potash; Aqua Kali puri; Lixivium Causticum*, or *Caustic Lye; Lixivium Saponarium*, or *Soap Boilers' Lye.*—This is a solution of caustic potash. The history of the preparation of caustic alkaline solutions has already been given (see *ante*, p. 463).

The *London College* orders of Carbonate of Potash, ℥xv.; Lime, ℥viij.; Distilled Water, boiling, *Cong.* j. Dissolve the Carbonate of Potash in half a gallon of the water. Sprinkle a little of the water upon the lime in an earthen vessel, and the lime being slacked, add the rest of the water. The liquors being immediately mixed together in a close vessel, shake them frequently until they are cold. Then set by [the mixture], that the carbonate of lime may subside. Lastly, keep the supernatant liquor, when poured off, in a well-stoppered green glass bottle.

The *Edinburgh College* directs of Carbonate of Potash (dry), ℥iv.; Lime recently burnt, ℥ij.; Water, f℥xlv. Let the lime be slaked, and converted into milk of lime, with seven fluidounces of the water. Dissolve the carbonate in the remaining thirty-eight fluidounces of water; boil the solution, and add to it the milk of lime in successive portions, about an eighth at a time,—boiling briskly for a few minutes after each addition. Pour the whole into a deep narrow glass vessel for twenty-four hours; and then withdraw with a syphon the clear liquid, which should amount to at least thirty-five fluidounces, and ought to have a density of 1·072.

The *Dublin College* employs of Carbonate of Potash, from Potashes of Commerce; Fresh burnt Lime, of each, two parts; Water, fifteen parts. [The process is not essentially different from that of the London College.] The sp. gr. of this product is 1·080.

In all these processes, the lime abstracts carbonic acid from the carbonate of potash, forming carbonate of lime, and the potash thus set free dissolves in the water: $KO,CO^2 + CaO = KO + CaO,CO^2$.



As more lime is usually employed than is sufficient to saturate the carbonic acid of the carbonate of potash, a portion of lime remains in solution. This may be got rid of by the addition of a solution of carbonate of potash as long as a precipitate forms.

The liquid should be decanted or drawn off by a syphon. Filters are objectionable, as the potash decomposes and partially dissolves them. Cotton and linen are less acted on by it than paper or woollen cloth, which are readily decomposed by it. The air must be excluded as much as possible during the process of filtration, as the liquor abstracts carbonic acid from the air.

The ebullition directed to be employed by the Edinburgh College has three advantages: it accelerates the chemical changes; it augments the density, and thereby promotes the subsidence of the carbonate of lime; and, lastly, it yields a purer product, as it effects the separation of the silica usually contained in the carbonate of potash, by giving rise to an insoluble combination of silica with lime and potash. But on the large scale, the inconvenience, expense, and danger attending the ebullition of considerable quantities of liquor potassæ, more than counterbalances, in ordinary cases, the advantages above mentioned.

Liquor potassæ is a limpid, colourless, transparent, inodorous liquid, having an acrid taste. Prepared according to the London Pharmacopœia, its sp. gr. is 1·063; according to the Edinburgh Pharmacopœia, 1·072; while, according to the Dublin College, it is 1·080. It has a soapy feel when rubbed between the fingers, and reddens yellow turmeric paper. It strongly attracts carbonic acid from the atmosphere, and, therefore, should be kept in closed vessels. It corrodes flint glass, and on that account should be preserved in green glass bottles.

If the carbonate of potash ($2KO,2CO^2,3HO$) used in the preparation of liquor potassæ (Ph. Lond.) were absolutely pure, this solution would contain 5·537 per cent. of anhydrous potash. But the commercial carbonate is never quite free from impurity, and, therefore, the actual strength of the liquor is somewhat below this. If we assume that the relative portions of potash and water were 1 atom potash and 90 atoms water, the composition would be as follows:—

	Atoms.	*Eq. Wt.*	*Per Centage.*
Potash	1	47	5·484
Water	90	810	94·516
Liquor potassæ	1	857	100·000

It usually contains a small quantity of carbonate of potash, which may be detected by lime water, which renders the liquid turbid, or by a diluted mineral (sulphuric or nitric) acid, which causes effervescence. Liquor potassæ is, however, rarely so pure as to stand the test of lime-water. But it should not effervesce when added to diluted nitric acid. The presence of a very small quantity of alkaline carbonate is unobjectionable: nay, it is advantageous, by preventing any lime being held in solution. When pure liquor potassæ has been saturated with diluted nitric acid, it gives no precipitate on the addition of carbonate of soda, chloride of barium, or nitrate of silver: if the first cause a precipitate, it would indicate some earthy or metallic impregnation; if there be a precipitate insoluble in nitric acid with the second, we infer the presence of a sulphate; and lastly, if the third occasion a precipitate soluble in ammonia, but insoluble in nitric acid, a chloride is present.

The effects and uses of this liquid have been above described. The dose of it is ten drops, gradually increased to the extent of a fluidrachm, or even more, carefully watching its effects. It may be conveniently exhibited in the infusion of orange-peel. With infusion of lemon-peel caustic potash forms a gelatinizing mixture (see *Citrus Limonum*). Table beer completely disguises the nauseous flavour of the alkali, but the vegetable acid of the beer partly neutralizes the alkali. Veal broth is another liquid for its administration. *Dr. Chittick's nostrum* for the stone is said to be a solution of alkali in veal broth.

BRANDISH'S ALKALINE SOLUTION.—Take of best American Pearlashes, lbvj.; Quicklime, fresh prepared; Woodashes (from the Ash), of each lbij.; Boiling Water, *Cong.* vj. Add first the lime, then the pearlashes, and afterwards the woodashes, to the boiling water; then mix. In twenty-four hours the clear liquor may be drawn off.—In this process the lime decomposes the carbonate of potash contained in pearlashes and woodashes, and combines with the carbonic acid, setting free the potash. The liquid, therefore, is a solution of caustic potash contaminated with some soluble alkaline salts (sulphate of potash and chloride of potassium). The solution is stronger than the officinal *liquor potassæ*, but is liable to vary in strength, in consequence of the varying quality of the ashes used.—Dose, according to Mr. Brandish, for an adult, is three (or even four) teaspoonfuls; for children, of from four to six years of age, one small teaspoonful; from six to eight years, a teaspoonful and a half; from eight to fifteen, two teaspoonfuls; and from fifteen to eighteen years, two teaspoonfuls and a half. The dose is to be taken twice daily, between breakfast and dinner and at bed-time, in fresh small beer or ale. A drop or two of oil of juniper covers the saponaceous taste, and gives a grateful smell. A generous regimen, and a careful avoidance of acids, were employed by Mr. Brandish, in conjunction with the alkaline liquor. In scrofulous tumours, mercurial ointment was rubbed in.

2. POTASSÆ HYDRAS, Ph. L.; *Potassa*, Ph. Ed.; *Potassa Caustica*, Ph. Dub.; *Potassa fusa; Kali purum; Lapis infernalis vel septicus; Cauterium potentiale.*—All the British Colleges give directions for the preparation of hydrate of potash.

The *London College* orders, of Solution of Potash, a gallon. Evaporate the water in a clean iron vessel over the fire, until the ebullition being finished, the Hydrate of Potash liquefies: pour this into proper moulds.

The *Edinburgh College* directs any convenient quantity of Aqua Potassæ to be evaporated in a clean and covered iron vessel, increasing gradually the heat till an oily-looking fluid remains, a drop of which, when removed on a rod, becomes hard on cooling: then pour out the liquid upon a bright iron plate, and as soon as it solidifies break it quickly, and put it into glass bottles secured with glass stoppers.

The process of the *Dublin College* is essentially the same as that of the Edinburgh College, except that the evaporation is to be effected in vessels of silver or iron, and the liquefied potash is to be poured out on a plate of silver or iron.

"During the preparation of the hydrate of potash, a solution of the potash becomes peroxide of potassium; but the additional oxygen thus acquired is expelled in the gaseous state during solution in water"—(*R. Phillips.*)

The solid hydrate of potash of the shops, commonly called *potassa fusa*, is usually found in the shops in sticks (*potassa fusa in baculis*). It is in general more or less coloured (brownish, greyish, or bluish), and not completely soluble in water and alcohol, in consequence of the presence of foreign matters. Pure hydrate of potash, however, is white, and dissolves in both water and alcohol. During its solution in water, heat is evolved. Its solubility in alcohol enables us to separate it from the carbonate and bicarbonate of potash, both of which are insoluble in this liquid. When purified by solution in alcohol, it constitutes the *potasse à l'alcool* of the French writers. It has a strong affinity for both water and carbonic acid, which it rapidly attracts from the atmosphere, and in consequence becomes liquid. At a low red heat it fuses, and at a higher temperature is volatilized. It is odourless, but has a caustic, urinous taste. It rapidly decomposes organic substances. It possesses the properties of an alkali in an eminent degree.

Its composition is as follows:—

	Atoms.	*Eq. Wt.*	*Per Cent.*	*Berzelius.*
Potash	1	47	83·93	84
Water	1	9	16·07	16
Hydrate of Potash	1	56	100·00	100

Potassa fusa of the shops contains various impurities, such as sesquioxide of iron, oxide of manganese, carbonate of potash, and silica. These, however, do not materially affect its medicinal value.

"Boiling water commonly leaves oxide of iron undissolved, which should not exceed 1·25 per cent.: the solution neutralized with nitric acid gives a faint precipitate with a solution of nitrate of baryta, and more with solution of nitrate of silver, owing to the presence of impurities."—*Ph. Ed.*

The nitrate of baryta detects sulphates, while nitrate of silver is a test for chlorides.

Hydrate of potash is exclusively employed as an escharotic. For some purposes its deliquescent property renders it inferior to nitrate of silver.

3. **POTASSA CUM CALCE**, L. E.; *Potassa Caustica cum Calce*, D.; *Causticum commune fortius; Potash with lime.*—It is sometimes called by continental writers *Pasta escharotica Londinensis.* A compound of potash and lime was used as a caustic by the Greeks under the name of πρωτόστακτον.[1] It was probably identical with *calx liquefacta vulgo colata* of Cælius Aurelianus.[2]

The following are the directions for preparing potassa cum calce.

According to the *London College*, Hydrate of Potash, and Lime, of each an ounce, are to be rubbed together, and kept in a well-stoppered vessel.

The *Edinburgh College* directs, that any convenient quantity of Aqua Potassæ be evaporated in a clean covered iron vessel to one third of its volume; add slacked lime till the fluid has the consistence of firm pulp: preserve the product in carefully-covered vessels.

The process of the *Dublin College* is similar to that of the Edinburgh College.

By admixture with lime, hydrate of potash is rendered less deliquescent. Potassa cum calce is employed as an escharotic in the same cases as potassa fusa. When used, it is made into a paste with rectified spirit, and applied to the part to be cauterized.

The *pulvis causticus* seu *escharoticus Viennensis* is composed of five parts of fused potash and six parts of caustic lime.

42. POTASSÆ CARBONATES.—CARBONATES OF POTASH.

HISTORY.—Two compounds of potash and carbonic acid are well known, and are employed in medicine. They are—

1. The Monocarbonate, or neutral carbonate of potash	KO,CO^2.
2. The Bicarbonate of Potash	$KO,2CO^2$.

A third, or sesquicarbonate, has been described, but its existence is problematical.

The monocarbonate was known to the ancients, though the real distinction between it and caustic potash was first explained by Dr. Black, in 1756. The bicarbonate was first obtained in 1757.

EFFECTS.—The general effects of the carbonates of potash are similar to, though milder than, those of caustic potash; and they are milder in proportion to the quantity of carbonic acid which they contain.

1. Potassæ Monocarbonas.—Neutral Carbonate of Potash.

Formula KO,CO^2. *Equivalent Weight* 69.

HISTORY.—It is probable that the ancient Greeks, Romans, and Egyptians, were acquainted with this salt. Pliny[1] describes some of the uses of wood-ashes, and mentions a lye of them (*cinis lixivius*). For a long period carbonate of potash was confounded with carbonate of soda. Geber,[2] in the eighth century, describes the method of procuring it by the combustion of tartar.

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[1] Paulus Ægineta, Adams's translation, vol. i. pp. 414 and 428; vol. ii. p. 265; vol. iii. p. 185.

[2] *Morb. Chron.* lib. v. cap. i. p. 554, ed. J. C. Amman, Amstel. 1722.

SYNONYMES.—In chemical and pharmaceutical works it is usually called *carbonate of potash* (*potassæ carbonas,* L. E. D.); but until very recently it was generally termed *subcarbonate of potash* (*potassæ subcarbonas*). It was formerly called *mild fixed vegetable alkali* or *prepared kali* (*kali præparatum*). According to the source from which it was obtained, or the mode of procuring it, it has had the various names of *salt of tartar* (*sal tartari*), *salt of wormwood* (*sal absinthii*), *salt of broom* (*sal genistæ*), *fixed nitre* (*nitrum fixum*), *white flux* (*fluxus albus*), &c.

NATURAL HISTORY.—Reuss[3] found carbonate of potash in the waters of the Wuissokow and in the chalybeate of Twer.

It is formed, during the combustion of inland plants, by the decomposition of the vegetable salts of potash (the acetate, the malate, and the oxalate, but principally the first). Hence it is procured in great abundance from wood-ashes. In some few cases it has been supposed to exist ready formed in plants, as in a fern referred to by Mr. Parkes,[4] the expressed juice of which is employed by the poor weavers of Yorkshire in the cleansing of cloth at the fulling mills.

PREPARATION. *a.* **Of Potashes and Pearlashes**; (*Potassa impura,* Ph. L.; *Lixivus cinis,* Ph. D.)—These are obtained from *wood-ashes* (*cineres vegetabilium* seu *cineres e lignis combustis*), which are procured by burning wood piled in heaps on the ground, sheltered from the wind, or in pits.[5] The soluble constituents of the ashes are *carbonate, sulphate, phosphate, and silicate of potash, and chlorides of potassium and sodium.* The insoluble constituents are *carbonate and subphosphate of lime, alumina, silica, the oxides of iron and manganese, and a dark carbonaceous matter.* In America the ashes are lixiviated in barrels with lime, and the solution evaporated in large iron pots or kettles, until the mass has become of a black colour and of the consistence of brown sugar. In this state it is called by the American manufacturers *black salts* (*cineres clavellati crudi*). The dark colour is said by Dumas to be owing to *ulmate of potash.*

To convert this substance into the *potashes* of commerce (*cineres clavellati calcinati*), it is heated for several hours, until the fusion is complete, and the liquid becomes quiescent. It is then transferred by large iron ladles into iron pots, where it congeals in cakes. These are broken up, packed in tight barrels, and constitute the *potashes* of commerce. Its colour varies somewhat, but it is usually reddish, in consequence of the presence of sesquioxide of iron.

To make the substance called *pearlash,* the mass called black salts, instead of being fused, is transferred from the kettles to a large oven-shaped furnace, constructed so that the flame is made to play over the alkaline mass, which in the meantime is stirred by means of an iron rod. The ignition is in this way continued until the combustible impurities are burnt out, and the mass, from being black, becomes dirty bluish-white: this is pearlash.[1] The colouring matter is probably manganesiate of potash.

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[1] *Hist. Nat.* lib. xiv. and xxviii.

[2] *Invent. of Verity,* ch. iv.

[3] Gairdner, *On Mineral Springs,* p. 18.

[4] *Chemical Essays,* vol. ii. p. 17.

[5] For an account of the preparation and composition of wood-ashes, see Berthier, *Traité des Essais,* t. 1er, p. 259, Paris, 1834.

The following table shows the composition of various kinds of potash and pearlash according to Vauquelin[2]:—

Kinds of Potash.	Caustic Hydrate of Potash.	Sulphate of Potash.	Chloride of Potassium.	Insoluble Residue.	Carbonic Acid and Water.
American Potash	857	154	20	2	119
Russian Potash...............	772	65	5	56	254
American Pearlash	754	80	4	6	308
Potash of Trèves	720	165	44	24	199
Dantzic Potash...............	603	152	14	79	304
Potash of Vosges	444	148	510	34	16

In this table it will be observed that the American potash contains the largest quantity of caustic potash: this arises, probably, from the use of lime in its manufacture.

Pearlash contains more carbonate of potash than potashes: this must arise from the absorption of carbonic acid during its preparation.[3] The potash and pearlash employed in this country are principally imported from the British North American colonies, from Russia, and from the United States of America.

β. Of Refined Potashes; *Potassæ Carbonas*, L. E.; *Potashes*, E.; *Potassæ Carbonas e Lixivo Cinere*, D.—The London and Dublin Colleges give directions for the preparation of this substance.

The *London College* orders of impure Carbonate of Potash, lbij.; Distilled Water, Oiss. Dissolve the impure Carbonate of Potash in the water, and strain; then pour it into a proper vessel, and evaporate the water, that the liquor may thicken; afterwards stir it constantly with a spatula until the salt concretes.

The *Edinburgh College* merely states that this preparation is "Carbonate of Potash not quite pure, obtained by lixiviating, evaporating, and granulating by fusion and refrigeration the potashes of commerce."

The *Dublin College* directs of Potashes, in coarse powder, of Cold Water, of each, *one part*. Mix, by rubbing them together, and macerate during a week in any open vessel, occasionally shaking the mixture. Then filter the lixivium, and let it evaporate to dryness in a perfectly clean silver or iron vessel. Towards the end of the evaporation let the saline mass be continually stirred with an iron rod. Thus reduced to a coarse powder, let it be laid by in close vessels. If the potashes be not sufficiently pure, before they are dissolved, let them be roasted in a crucible until they become white.

By the above proceedings the earthy impurities, insoluble in water, are got rid of.

γ. Of Pure Carbonate of Potash; *Potassæ Carbonas purum*, E.; *Potassæ Carbonas e Tartari Crystallis*, D.—All the British Colleges give directions for the preparation of this substance.

The *London College* states that Carbonate of Potash may be prepared more pure [than the carbonate above referred to] from the crystals of Bicarbonate of Potash, heated to redness.

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[1] *United States Dispensatory.*

[2] *Ann. de Chim.* xl. 273.

[3] For the mode of estimating the quantity of alkali present, see Mr. Faraday's *Chemical Manipulation*, art. *Alkalimetry;* also Brande's *Manual of Chemistry*, 5th edit.

The *Edinburgh College* observes, that Pure Carbonate of Potash may be most readily obtained by heating crystallized Bicarbonate of Potash to redness in a crucible, but more cheaply by dissolving Bitartrate of Potash in thirty parts of boiling water, separating and washing the crystals which form on cooling; heating these in a loosely-covered crucible to redness so long as fumes are discharged; breaking down the mass and roasting it in an open crucible for two hours, with occasional stirring, lixiviating the product with distilled water, filtering the solution thus obtained, evaporating the solution to dryness, granulating the salt towards the close by brisk agitation, and heating the granular salt nearly to redness. The product of either process must be kept in well-closed vessels.

The process of the *Dublin College* is as follows:—Take of Crystals of Tartar any required quantity; heat them to redness in a silver crucible lightly covered, until they cease to emit vapours. Let the residue be reduced to a coarse powder, and roasted in the same crucible without a cover, with frequent stirring, during two hours: then boil it with twice its weight of water during a quarter of an hour, and after the requisite subsidence pour off the clear liquor. Let this be done three times. Filter the mixed washings, and let them evaporate in a silver vessel. Let the residual salt, whilst becoming dry, be reduced by frequent stirrings to a granular form; then let it be heated to an obscure red. Before it has perfectly cooled take it from the vessel, and preserve it in well-stoppered bottles.

When bicarbonate of potash is submitted to a low red heat it loses half its carbonic acid, and is converted into the carbonate.

When bitartrate is ignited, various volatile substances are evolved, and the residue in the crucible is a mixture of charcoal and carbonate of potash, and is denominated *black flux* (*fluxus niger*). "If made with raw tartar, which contains nitrogen, it is contaminated with bicyanide of potassium" (Turner). By roasting, the charcoal is burnt off, and nearly pure carbonate of potash is obtained from the residue by lixiviation. The carbonate thus produced is called *salt of tartar* (*sal tartari*).

By deflagrating a mixture of equal parts of bitartrate of potash and nitrate of potash we obtain carbonate of potash contaminated with hyponitrate and even with some undecomposed nitrate of potash. The residue is called *white flux* (*fluxus albus*).

By deflagrating a mixture of nitre and charcoal we obtain what is called *fixed nitre* (*nitrum fixum*).

The high price of pearlash has occasionally led to the manufacture of carbonate of potash from *sal enixum* (bisulphate of potash), by heating it in a reverberatory furnace with charcoal. This yields a sulphuret of potassium, in consequence of the carbon deoxidizing the bisulphate. By roasting, this sulphuret is decomposed, and converted into carbonate of potash; the sulphur being dissipated, and the potassium combining with oxygen and carbonic acid.

PROPERTIES.—Carbonate of potash is usually kept, in the shops, in a granular condition, on account of the difficulty of crystallizing it. In this state it is commonly denominated *subcarbonate of potash* (*potassæ subcarbonas*) or *salt of tartar* (*sal tartari; sal absinthii; kali præparatum*). It is white, inodorous, and strongly alkaline to the taste. It reacts powerfully as an alkali on turmeric. It changes the red colour of the sulphate of red cabbage to a blue, and restores the blue colour of reddened litmus. It is fusible at a red heat; has a strong affinity for water, so that by exposure to the air it attracts water and becomes liquid, forming the *oleum tartari per deliquium*. It is insoluble in alcohol, but is very soluble in water.

Pure carbonate of potash may, though with some difficulty, be crystallized from its aqueous solution. The crystals are rhombic octohedrons, and belong to the right prismatic system (see *ante*, pp. 141-2).

Characteristics.—It is known to be a carbonate by its effervescing with the strong acids, and by a solution of it causing a white precipitate (soluble in acetic acid) with lime water or with chloride of barium (see the tests for the *carbonates*, p. 318). That it is a potash salt is determined by the tests for potash already mentioned (see *ante*, p. 463). From the bicarbonate of potash it is distinguished by a solution of bichloride of mercury causing a brick-red precipitate. The presence of chloride of sodium checks or prevents the formation of this precipitate. Sulphate of magnesia produces a white precipitate with the carbonate of potash, and not with the bicarbonate. This test, however, will not recognize the carbonate when mixed with a large quantity of bicarbonate.

COMPOSITION.—Pure anhydrous carbonate of potash has the following composition:—

	Atoms.	*Eq. Weight.*	*Per Cent.*	*Vauquelin.*	*Ure.*
Potash	1	47	68·12	67	68·6
Carbonic Acid	1	22	31·88	33	31·4
Neutral Carbonate of Potash	1	69	100·00	100	100·0

According to Mr. Phillips[1] the granulated carbonate of potash of the shops contains about 16 per cent. of water, which it loses when heated to redness. The crystallized salt contains two atoms of water.

	At.	*E.Wt.*	*P. Ct.*	*Phillips.*
Carbonate of Potash	1	69	83·64	84
Water	1½	13·5	16.36	16
Granulated Carb. of Potash	1	82·5	100·00	100

	At.	*E.Wt.*	*P.C.*	*Phillips.*
Carbonate of Potash	1	69	79·31	79
Water	2	18	20·69	21
Crystallized Carb. of Potash	1	87	100·00	100

In this table I have assumed the granulated carbonate of potash to be pure, which the salt of commerce never is.

IMPURITIES.—The ordinary impurities in this salt are water, silicic acid, the chlorides and sulphates. The first is detected by the loss of weight which the salt suffers by heat; the second is recognised by supersaturating with hydrochloric acid, evaporating, and igniting the residue: the silicic acid is insoluble in water. The other impurities are detected by supersaturating the salt with nitric acid: if the resulting solution give a white precipitate with nitrate of silver, the presence of a chloride is to be inferred; if it produce a white precipitate with chloride of barium a sulphate is present. Other impurities mentioned by L. Gmelin are phosphate of potash, nitrate or hyponitrite of potash, cyanide of potassium, soda, and carbonate of lime. To detect the phosphate, boil with excess of hydrochloric acid to expel all the carbonic acid: then add some chloride of calcium and excess of caustic ammonia: a flocculent precipitate of phosphate of lime is formed. If nitrate or hyponitrite be present, dissolve in oil of vitriol and add a solution of sulphates of iron, when a reddening is perceived (see *ante*, pp. 356 and 412). Cyanide of potassium is detected by adding a solution of the mixed sulphate of iron and then hydrochloric acid: prussian blue is formed. To detect soda, saturate with acetic acid, evaporate to dryness, dissolve the residue in spirit of wine, and precipitate the potash by bichloride of platinum: add sulphuric acid to the filtered liquor and evaporate, and ignite the residue: then treat with water, evaporate the solution thus obtained, and by cooling easily recognised crystals of sulphate of soda are obtained. Some carbonate of lime is held in solution by carbonate of potash, but by long standing it deposits. To detect it, saturate with acetic acid and then add oxalic acid, a white precipitate of oxalate of lime is obtained.

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[1] *Translation of the Pharmacopœia*, p. 284, 4th edit. 1841.

The *London College* states the following to be the characters of good carbonate of potash:—

> Almost entirely dissolved by water; in an open vessel it spontaneously liquefies. It changes the colour of turmeric brown. When supersaturated with nitric acid, neither carbonate of soda nor chloride of barium throws down any thing, and nitrate of silver but little. 100 parts lose 16 of water by a strong heat; and the same quantity loses 26·3 parts of carbonic acid on the addition of dilute sulphuric acid.

The *Edinburgh College* states, that

> "100 grains [*of commercial carbonate of potash*] lose not more than 20 on exposure to a red heat: and, when dissolved and supersaturated by pure nitric acid, the solution gives a faint haze with solution of nitrate of baryta, and is entirely precipitated by 100 minims of solution of nitrate of silver."—*Ph. Ed.*
>
> *Pure Carbonate of Potash* "does not lose weight at a low red heat: and a solution supersaturated with pure nitric acid is precipitated either faintly, or not at all, by solution of nitrate of baryta or nitrate of silver."

PHYSIOLOGICAL EFFECTS.—Its effects are in *quality* precisely those of caustic potash already described, but their *intensity* is much less, on account of the presence of carbonic acid, which diminishes the alkaline properties of the base. When it is taken into the stomach in large quantities, it acts as a powerfully caustic poison, sometimes inducing death in twelve hours, and producing symptoms similar to those caused by the mineral acids: at other times, however, the patient recovers from the immediate effect of the alkali, but, in consequence of the altered condition of the alimentary canal, the assimilative process cannot be carried on; and, after dragging on a miserable existence for a few weeks the unfortunate sufferer dies of absolute starvation. And, lastly, in some cases, the caustic operation of the poison is principally confined to the œsophagus, causing stricture and death. In a case related by Sir Charles Bell,[1] a patient swallowed soap lees, which produced inflammation, terminating in stricture. She lingered for twenty years, and died literally starved. Several other cases have been detailed.[2] In one case no vomiting occurred, but death took place from suffocation.[3] A weak solution of carbonate of potash produces no change in the sanguineous particles drawn from the body: a saturated solution slightly and gradually diminishes their size.

USES.—This salt is employed, in medicine, in most of the cases already mentioned when describing the uses of caustic potash. For example, as an antacid in dyspeptic affections; as a diuretic; as an antacid in that form of lithiasis which is accompanied with an increased secretion of lithic acid, or the lithates; in those forms of inflammation in which there is a tendency to the formation of false membranes; in gout, &c. On the recommendation of Mascagni,[4] it has been employed in peripneumonia and other inflammatory diseases with benefit (see *ante*, p. 178). Mixed with cochineal it is a popular remedy for hooping-cough. Externally, it has been applied in the form of a solution to wounds; as an injection in gonorrhœa; as a collyrium in some affections of the cornea, &c. Lastly, it is sometimes employed in the manufacture of the common effervescing draught, made with either the citric or tartaric acid.

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[1] *Surgical Observations*, part i. p. 82.

[2] Christison, *On Poisons.*

[3] *Lancet*, 1834-5, vol. ii. p. 660.

[4] *Memoria della Società Italiana delle Scienze*, t. xi. Modena, 1804. Negri, *Lond. Med. Gaz.* vol. xiv. p. 713.

20 grs. of Carbonate of Potash are saturated by about { 17 grs. of commercial crystals of Citric Acid,
18 grs. of crystals of Tartaric Acid,
4 fluidrachms of Lemon Juice.

ADMINISTRATION.—It may be given either in the solid or liquid state. In the solid state it is given in doses of from gr. x. to ʒss.

ANTIDOTES.—When swallowed as a poison, the antidotes are oils or acids, as already mentioned for caustic potash.

LIQUOR POTASSÆ CARBONATIS, L.; *Potassæ Carbonatis Aqua*, D.; *Aqua Kali; Solution of Carbonate of Potash; Liquamen Tartari*, seu *Oleum Tartari per deliquium; Lixivium Tartari; Aqua Kali præparati; Liquor Potassæ Subcarbonatis*. (Carbonate of Potash, ℥xx.; Distilled Water, Oj. dissolve and strain, *L.*; Carbonate of Potash from crystals of Tartar, *one part*; Distilled Water, *two parts*. Dissolve and filter. The sp. gr. of this solution is 1·320.) — A colourless, inodorous solution. Prepared according to the London Pharmacopœia, its sp. gr. is 1·473. That of the Dublin College is 1·320.—Dose, ♏x. to fʒj.

2. Potassæ Bicarbonas.—Bicarbonate of Potash.

Formula $KO,2CO^2,HO$. *Equivalent Weight* 100.

HISTORY.—This salt, formerly called *carbonate of potash* or *aërated kali*, was first prepared by Cartheuser, in 1757. It is sometimes called *Berthollet's neutral carbonate of potash*. Wollaston first demonstrated that this salt contained twice as much acid as the preceding one.

PREPARATION.—All the British Colleges give directions for its preparation:

The *London College* orders it to be prepared with Carbonate of Potash, lbvj.; Distilled Water, *Cong.* j. Dissolve the Carbonate of Potash in the Water, afterwards pass Carbonic Acid through the solution to saturation. Apply a gentle heat, so that whatever crystals have been formed may be re-dissolved. Then set aside (the solution), that the crystals may be again produced: the liquor being poured off, dry them.

Carbonic acid is very easily obtained from chalk, rubbed to powder, and mixed with water, to the consistence of a syrup, upon which Sulphuric Acid is then poured, diluted with an equal weight of Water.

The process of the *Dublin College* is similar, except that when the solution becomes turbid [from the precipitation of silicic acid], it is to be filtered, and again exposed to the stream of carbonic acid gas. The gas is ordered to be generated by the action of diluted muriatic acid on white marble.

In this process each equivalent of carbonate of potash unites with an additional equivalent of carbonic acid, and thereby forms the bicarbonate. The silicic acid is separated partly while the carbonic acid is passing through the solution, and partly during the crystallization of the bicarbonate.

At Apothecaries' Hall, London, the process is conducted in two iron vessels; in one of which carbonic acid is generated (by the action of sulphuric acid on whiting), in the other is contained the solution of carbonate of potash, through which the carbonic acid is passed. "The following proportions may be used for the preparation of bicarbonate of potassa upon the large scale:—100 lbs. of purified carbonate of potassa are dissolved in 17 gallons of water, which, when saturated with carbonic acid, yield from 35 to 40 lbs. of crystallized bicarbonate; 50 lbs. of carbonate of potassa are then added to the mother-liquor, with a sufficient quantity of water to make up 17 gallons, and the operation repeated (*Hennell*)."[1] Sulphuric is preferable to muriatic acid for generating carbonic acid, as being both cheaper and less volatile.

The *Edinburgh College* directs it to be prepared from Carbonate of Potash, ℥vj.; and Carbonate [Hydrated Sesquicarbonate] of Ammonia, ℥iijss. Triturate the Carbonate of Ammonia to a very fine powder; mix with it the Carbonate of Potash; triturate them thoroughly together, adding by degrees a very little Water, till a smooth and uniform pulp be formed. Dry this gradually at a temperature not exceeding 140°, triturating occasionally towards the close, and continue the desiccation till a fine powder be obtained, entirely free of ammoniacal odour.

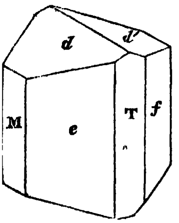
In this process the volatility of the ammonia and the affinity of the carbonate of potash for more carbonic acid, together cause the decomposition of the sesquicarbonate of ammonia: the ammonia, with a small portion of carbonic acid, is disengaged, while the remaining acid converts the carbonate into the bicarbonate of potash.

The process adopted by the Edinburgh College is that commonly known as *Cartheuser's process.* MM. Henry and Guibourt[2] give the following directions for its performance:—

Dissolve 500 parts of (pure) carbonate of potash in 1000 parts of distilled water, and filter; place the solution in a porcelain capsule in a salt-water bath, and gradually add 300 parts of pulverized carbonate of ammonia; slightly agitate the liquor until only a feeble disengagement of ammonia is perceived, then filter over a heated vessel, and put aside to cool. The proportions employed by Geiger[3] are somewhat different: they are—a pound of carbonate of potash, sixteen ounces of water, and six ounces of carbonate of ammonia.

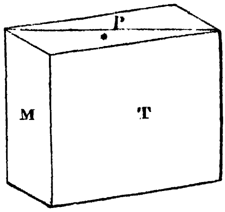
PROPERTIES.—It is a crystalline, colourless solid. The crystals belong to the oblique prismatic system. The primary form is, according to Mr. Brooke,[4] a right oblique-angled prism. It is inodorous, has an alkaline taste, and reacts very feebly as an alkali on vegetable colours. It is soluble in four times its weight of water at 60° F., but is insoluble in alcohol. When exposed to the air, it undergoes no change. When exposed to a red heat, it gives out half its carbonic acid, and becomes the carbonate.

FIG. 76.



Modified prism of Carbonate of Potash.

FIG. 77.



Prism derived by Cleavage.

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[1] Brande, *Manual of Chemistry*, 5th edit. p. 642, Lond. 1841.

[2] *Pharmacopée Raisonnée*, 3me éd. p. 605, Paris, 1841.

[3] *Handbuch der Pharmacie*, 3tte Aufl.

[4] *Annals of Philosophy*, N. S. vol. vi. p 42; also Levy, in *Quarterly Journal of Science*, vol. xv.

Characteristics.—The presence of carbonic acid and potash in this salt is known by the tests for these substances before mentioned. From the carbonate of potash it is best distinguished by a solution of bichloride of mercury, which causes a slight white precipitate or opalescence with it; whereas with the carbonate it causes a copious brick-red precipitate. This test, however, will not, under all circumstances, detect the carbonate; as when the quantity is very small, or when chloride of sodium is present. Sulphate of magnesia will not prove the total absence of carbonate, as I have before stated (see *ante*, p. 475).

COMPOSITION.—The composition of this salt is as follows:—

	Atoms.	*Eq. Wt.*	*Berard.*	*Vauquelin.*
Potash	1	47	48·92	46
Carbonic Acid	2	44	42·01	47
Water	1	9	9·07	7
Crystallized Bicarbonate Potash	1	100	100·00	100

IMPURITIES.—The presence of chlorides and sulphates may be recognised in this salt as in carbonate of potash (see *ante*, p. 475). Bichloride of mercury may be employed to detect carbonate of potash, with which it forms a brick-red coloured precipitate.

Totally dissolved by water, and the solution slightly changes the colour of turmeric. Sulphate of magnesia throws down nothing from this solution, unless it be heated. From 100 parts, 30·7 are expelled by a red heat. After the addition of excess of nitric acid, chloride of barium throws down nothing, and nitrate of silver very little, if any thing.—*Ph. Lond.*

"A solution in 40 parts of water does not give a brick-red precipitate with solution of corrosive sublimate; and when supersaturated with nitric acid, is not affected by solution of nitrate of baryta or nitrate of silver."—*Ph. Ed.*

PHYSIOLOGICAL EFFECTS.—The effects of this salt are similar to those of the carbonate of potash, except that its local action is much less energetic, in consequence of the additional equivalent of carbonic acid. Hence it is an exceedingly eligible preparation in lithiasis (see *ante*, p. 259) and other cases where we want its constitutional, and not its local, action.

USES.—It may be employed for the same purposes as caustic potash, except that of acting as an escharotic. Thus it is used as an antacid, to modify the quality of urine, in plastic inflammation, in glandular diseases, affections of the urinary organs, &c. It is the active ingredient of a popular lithonlytic called *constitution water*. But its most frequent use is that for making effervescing draughts, with either citric or tartaric acid. The proportions are as follows:—

20 grs. of crystallized Bicarbonate of Potash are saturated by about	14 grs. of commercial crystals of Citric Acid,
	15 grs. of crystallized Tartaric Acid,
	3½ drachms of Lemon Juice.

Where there is great irritability of stomach, I believe the effervescing draught, made with bicarbonate of potash and citric acid, to be more efficacious than that made with carbonate of soda and tartaric acid. The citrate of potash which is formed promotes slightly the secretions of the alimentary canal, the cutaneous transpiration, and the renal secretion; and, like other vegetable salts of potash, renders the urine alkaline.

ADMINISTRATION.—This salt may be given in doses of from gr. x. to gr. xv., or to the extent of half a drachm, or even a drachm.

1. **LIQUOR POTASSÆ EFFERVESCENS**, L.; *Potassæ Aqua Effervescens*, E.; *Effervescing Solution of Potash; Potash Water.* (Bicarbonate of Potash, ʒj.; Distilled Water, Oj. Dissolve the Bicarbonate of Potash in the Water, and pass into it of Carbonic Acid, compressed by force, more than sufficient for saturation. Keep the solution in a well-stoppered vessel.)—This is a solution of bicarbonate of potash surcharged with carbonic acid. It is an agreeable mode of exhibiting bicarbonate of potash, without injuring its medicinal power. It may be extemporaneously imitated by pouring a bottle of soda-water (i. e. *carbonic acid water*) into a tumbler containing grs. xx. of bicarbonate of potash.

2. **LEMON AND KALI.**—Under this name is kept in the shops a mixture professedly composed of powdered white sugar, dried and powdered citric acid, and powdered bicarbonate of potash; but on account of its deliquescence the citric acid is usually replaced by tartaric acid. This mixture is employed as an extemporaneous effervescing draught. As it abstracts water from the atmosphere, it must be preserved in a well-stoppered bottle (see *Pulveres Effervescentes*, Ph. Ed.)

43. POTASSII TERSULPHURETUM.—TERSULPHURET OF POTASSIUM.

Formula KS^3. *Equivalent Weight* 87.

HISTORY.—Geber[1] was acquainted with the solubility of sulphur in an alkaline solution; but Albertus Magnus taught the method of procuring sulphuret of potassium by fusion. The preparation kept in the shops under the name of *sulphuret of potassium* (*potassii sulphuretum*, L. E.) or *sulphuret of potash* (*potassæ sulphuretum*, D.) is a mixture of tersulphuret of potassium (to which it owes its essential properties) and some oxysalts of potash. It was formerly frequently called *liver of sulphur* (*hepar sulphuris*).

PREPARATION.—The process for the preparation of this compound is the same in all the British Pharmacopœias.

Take of Sulphur, ℥j.; Carbonate of Potass, ℥iv. Rub them together, and place them upon the fire, in a covered crucible, until they have united.

When sulphur and commercial carbonate of potash are fused together, water and carbonic acid are evolved. Part of the potash is decomposed; its potassium combining with sulphur to form a sulphuret of potassium; while its oxygen unites with sulphur to form one or more acids which combine with some undecomposed potash. A portion of the carbonate of potash remains undecomposed.

Assuming with Berzelius, that a tersulphuret of potassium and sulphate of potash are produced, the following equation represents the changes:—$10\,S + 4(KO,CO^2) = 3(KS^3) + KO,SO^3 + 4CO^2$. The excess of carbonate of potash employed is presumed to remain unchanged.

PROPERTIES.—When fresh prepared, it has a liver-brown colour; and hence its name *hepar sulphuris*. Its taste is acrid, bitter, and alkaline. If quite dry it is inodorous, but when moistened it acquires the odour of hydrosulphuric acid. Exposed to the air it undergoes decomposition, from the action of the aqueous vapour and oxygen. It becomes green and moist, and ultimately whitish. This change depends on the absorption of oxygen, in consequence of which part of the sulphur is deposited, while a portion of the sulphuret of potassium is converted into hyposulphite, afterwards into sulphite, and ultimately into sulphate of potash. Sulphuret of potassium is soluble in water.

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[1] *Invention of Verity*, chap. vi.

Characteristics.—Hydrochloric acid causes the evolution of hydrosulphuric acid gas and the precipitation of sulphur; the solution of the sulphuret in water produces a reddish or black precipitate with a solution of lead. That it contains potassium may be determined thus:—Add excess of hydrochloric acid to a solution of it; boil, and filter. The before-mentioned tests for potash (see p. 463) may then be applied.

> "Fresh broken it exhibits a brownish-yellow colour. Dissolved in water, or in almost any acid, it exhales a smell of hydrosulphuric acid. The aqueous solution is of a yellow colour. What is thrown down by acetate of lead is first red, and it afterwards blackens." —*Ph. L.*

COMPOSITION.—Berzelius[1] says, that if 100 parts of carbonate of potash be fused with 58·22 of sulphur, the product is a mixture of three equivalents of tersulphuret of potassium and one equivalent of sulphate of potash; and he adds, that if less than the above proportion of sulphur be employed, a portion of carbonate of potash remains undecomposed. But Winckler[2] has shewn, that if the carbonate employed be quite pure, and the operation be very carefully conducted, no sulphate is obtained, but hyposulphite and sulphite of potash. He fused together 900 grs. of crystallized basic carbonate of potash (dried at 212° F.) with 518 grs. of washed flowers of sulphur. The percentage composition of the product was as follows:—

Tersulphuret of Potassium	53·2905
Hyposulphite of Potash	29·4580
Sulphite of Potash	6·8613
Sulphate of Potash	0·7730
Carbonate of Potash	2·8780
Loss	6·7392
Hepar Sulphuris	100·0000

PHYSIOLOGICAL EFFECTS. *α. On Vegetables.*—There can be no doubt but that this compound is a powerful poison to plants, though I am not acquainted with any experiments made with it.

β. On Animals generally.—From the experiments of Orfila[3] on dogs, sulphuret of potassium appears to be a powerful narcotico-acrid poison. Six drachms and a half, dissolved in water, and introduced into the stomach, caused convulsions and death in seven minutes.

γ. On Man.—Its general action has already been referred to (see *ante*, p. 183). Its effects are analogous to those of hydrosulphuret of ammonia (see *ante*, p. 453). In *small doses* (as from four to ten grains) it acts as a general stimulant; increasing the frequency of the pulse, augmenting the heat of the body, promoting the different secretions, more especially those of the mucous membranes, and sometimes exciting local irritation, marked by pain, vomiting, and purging. By continued use it acts as a resolvent or alterative; and, on this account, is employed in certain forms of inflammation.

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[1] *Traité de Chimie*, t. ii. p. 301, Paris, 1831.

[2] *Berlinisches Jahrbuch*, Band xli. S. 321, 1839. A corrected abstract of this paper is contained in the *Pharmaceutisches Central-Blatt für* 1839, S. 547.

[3] *Toxicologie Générale.*

In *large doses* it is an energetic narcotico-acrid poison. In two instances it proved fatal in fifteen minutes: the symptoms were, acrid taste, slight vomiting, mortal faintness, and convulsions, with an important chemical sign, the tainting the air of the chamber with the odour of hydrosulphuric acid.[1]

Its local action is that of a powerful irritant: hence the acrid taste, burning pain, and constriction in the throat, gullet, and stomach, with vomiting and purging. But the nervous system also becomes affected; as is proved by the faintness, the almost imperceptible pulse, the convulsions, and (in some cases) sopor. These symptoms are analogous to those caused by hydrosulphuric acid; which, in fact, is copiously developed in the stomach.

It probably acts chemically on the blood, like sulphuretted hydrogen (see *ante*, pp. 108, 183, and 364).

Uses.—Internally, it has been administered in very obstinate skin diseases, such as lepra and psoriasis, which have resisted all the ordinary means of cure. It has also been employed as a resolvent in inflammations attended with lymphatic exudation, as croup, and in glandular enlargements. In chronic rheumatism, gout, hooping-cough, and various other diseases, against which it was formerly employed, it is now rarely if ever administered. It ought not to be given as an antidote for metallic poisoning, since it is itself a powerful poison.

Externally, it is applied in the form of lotions, baths, or ointment, in chronic skin diseases, such as eczema, scabies, lepra, pityriasis, &c.

Administration.—Internally it may be administered in the dose of three or four grains gradually increased. It may be given either in solution, or in the form of pill made with soap. For external use it is employed in solution in water, either as a bath or wash, or in the form of ointment. *Lotions* are sometimes made by dissolving an ounce of the sulphuret in two or three quarts of water. The *ointment* is composed of ʒss. of sulphuret to ℥j. of lard.

Antidotes.—In the event of poisoning by this substance, the antidote is a solution of chloride of soda, or of chloride of lime.

1. SOLUTIO POTASSII SULPHURETI; *Potassæ Sulphureti Aqua*, D. (Washed Sulphur, 1 part; Water of Caustic Potash, 11 parts. Boil during ten minutes, and filter through paper. Let the liquor be kept in well-closed vessels. The sp. gr. of this liquid is 1·117).—By the mutual reaction of sulphur and potassa, aided by the water and heat, a solution of sulphuret of potassium and hyposulphite of potash is obtained. The colour of this preparation is deep orange. It is sometimes administered in scabies, tinea capitis, and other allied eruptive diseases.—Dose, from ♏x. to fʒj. sufficiently diluted with water.

2. BALNEUM SULPHURATUM; *Sulphurated* or *Sulphurous Bath.* This is prepared by dissolving ℥iv. of sulphuret of potassium in 30 gallons of water (Rayer). For some purposes a small proportion of sulphuret (as ℥ij.) will be sufficient. It should be prepared in a wooden bathing vessel.—Used in obstinate skin diseases, as lepra and scabies. If an acid be added to this bath, sulphur is precipitated and sulphuretted hydrogen evolved. Care must be taken lest asphyxia be produced by the inhalation of the latter (see *ante*, p. 364). This bath is an important and valuable agent in the treatment of saturnine poisoning (see *ante*, p. 188), especially lead colic, saturnine arthralgia, and paralysis from lead. It renders brown or black and destroys the poisonous qualities of any portions of lead contained on the skin; and thereby prevents the further absorption of the poison. The hands, arms, buttocks, and other parts of the body of painters and workmen in white lead manufacturies, are sometimes completely blackened by it:[1] but the blackness is readily removed by a brush. The hair follicles frequently contain plumbeous particles, and are in consequence blackened by the bath. The benefit obtained by the use of the sulphurated bath does not appear to me merely of a preventive nature; but the great relief from already existing symptoms which patients usually obtain by the use of this bath, induces me to believe that the sulphuret becomes absorbed and acts in the system as a counterpoison, rendering inert the lead which has already been taken up.

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[1] Christison, *Treatise on Poisons*, p. 228.

3. **BALNEUM SULPHURATUM ET GELATINOSUM**; *Dupuytren's Gelatino-Sulphurous Bath.* This is prepared by adding one pound of glue (previously dissolved in water) to the sulphuretted bath above described.—It may be used as a substitute for the waters of Barèges; the glue representing the *Baregine*, an organic matter found in these waters. Barèges waters have been celebrated for cleansing foul ulcers, healing old wounds, and curing obstinate skin diseases.

44. POTASSÆ SULPHATES.—SULPHATES OF POTASH.

Three compounds of potash with sulphuric acid are known: they are the following:—

1. Monosulphate or the neutral sulphate of potash	KO,SO^3
2. Sesquisulphate of potash	$2KO,3SO^3,HO$
3. Bisulphate of potash	$KO,2SO^3,HO$

It will be perceived from this table that the so-called sesquisulphate contains the sum of the constituents of the two other salts.

1. Potassæ Monosulphas.—Neutral Sulphate of Potash.

Formula KO,SO^3. *Equivalent Weight* 87.

HISTORY.—The mode of preparing sulphate of potash was taught by Oswald Croll, in 1643. This salt has been known by various appellations, such as *specificum purgans paracelsi*, *arcanum duplicatum*, *vitriolated kali* (*kali vitriolatum*) *vitriolated tartar*, (*tartar vitriolatum*) *nitrum*

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[1] A very intelligent pupil of mine (Mr. J. L. Wyatt), who had repeatedly seen the beneficial effects of this bath on patients under my care at the London Hospital, recommended its employment to a medical friend, who then had under treatment a patient supposed to be suffering from the effects of lead. The bath appears to have been most successful; but the practitioner lost his patient in consequence: for, various parts of the body becoming of a deep-brown colour, the patient and his friends were firmly persuaded that the doctor had been trying experiments on him, and, consequently, on the following day the practitioner was informed that his services were no longer required!

vitriolatum sal polychrest (literally signifying *salts of many uses* or *virtues*), *sal de duobus*, &c. It is the *sulphate of potash* (*potassæ sulphas*) of the Pharmacopœia.

NATURAL HISTORY.—Sulphate of potash is found in both kingdoms of nature.

α. IN THE INORGANISED KINGDOM.—It has been met with in small quantities in some mineral waters of Saxony and Bohemia, in native alum, in alum-stone, and in a mineral called *polyhalite*, in which Stromeyer found no less than 27·6 per cent. of the sulphate of potash.

β. IN THE ORGANISED KINGDOM.—It has been found in the root of Polygala Senega, Winter's bark, the bulb of garlic, myrrh, opium, &c. The blood and urine of man also contain it.

PREPARATION.—It is prepared from the residuum of the distillation of nitric acid.

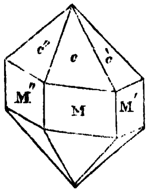
The *London College* orders of the salt which remains after the distillation of Nitric Acid, lbij.; Boiling Water, *Cong.* ij. Ignite the salt in a crucible until the excess of sulphuric acid is entirely expelled, then boil it in the two gallons of water until a pellicle floats, and the liquor being strained, set it aside that crystals may be formed. The liquor being poured off, dry them.

The *Edinburgh* and *Dublin Colleges* order the salt left after the distillation of nitric acid to be dissolved in water, and its excess of acid to be saturated. The Edinburgh College employs for this purpose white marble (carbonate of lime); while the Dublin College uses carbonate of potash. The neutral solution of sulphate of potash is then to be evaporated and crystallized.

The heat employed by the London College is to drive off the excess of sulphuric acid.

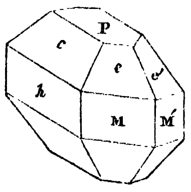
PROPERTIES.—It usually crystallizes in single or double six-sided pyramids. The two pyramids are sometimes united at a common base, or are separated by a short intervening prism (figs. 78 and 79). These forms agree very closely with those belonging to the rhombohedral system. But they have been shewn by Dr. Brewster[1] to be composite crystals; being composed of several crystals belonging to the right prismatic system, agglutinated so as to simulate the forms of the rhombohedral system. If a plate, cut perpendicular to the axis of the double pyramid, be examined by polarized light, it presents the tessellated structure shewn in fig. 81; and each of the six equilateral triangles are found to have two axes of double refraction.

FIG. 78.



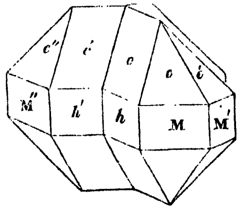
Common bipyramidal crystal with short intervening prism.

FIG. 79.



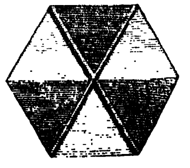
Ditto modified.

FIG. 80.



Compound crystal composed of three so united that their upper edges meet at angles of 120°.

FIG. 81.



Tessellated appearance of a plate of sulphate of potash seen by polarized light.

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[1] *Edinburgh Philosophical Journal*, vol. i. p. 6, Edinb. 1819.—See also Mr. W. Phillips, *Annals of Philosophy*, N. S. vol. iv. p. 342, Lond. 1822; Levy, *Quarterly Journal of Science*, vol. xv. p. 285, Lond. 1823; and Mr. Brookes, *Ibid.* N. S. vol. vii. p. 20, 1824.

Crystals of sulphate of potash are hard, inodorous, have a saline bitter taste, and are unchanged by exposure to the air. When heated they decrepitate. At 60° F. they require sixteen times their weight of water to dissolve them: they are insoluble in alcohol. A solution of them is decomposed by tartaric acid, which forms crystals of bitartrate of potash.

Characteristics.—The characteristics are those of a sulphate (see *ante*, p. 355), and of a potash salt (see *ante*, p. 463). To these must be added the crystalline form and solubility of the salt.

COMPOSITION.—The crystals contain no water of crystallization. They are thus composed:—

	Atoms.	*Eq. Wt.*	*Per Cent.*	*Wenzel.*	*Kirwan.*
Sulphuric Acid	1	40	45·977	45·25	45
Potash	1	47	54·023	54·75	55
Sulphate of Potash	1	87	100·000	100·00	100

PHYSIOLOGICAL EFFECTS.—Sulphate of potash, when given in moderate doses, usually operates as a mild purgative, without occasioning heat, pain, or any other symptoms of irritation. In doses of from fifteen to thirty grains, I have used it in hundreds of cases, in combination with a third part of powdered rhubarb, without having ever witnessed any injurious effects therefrom. I have also given it, but more rarely, in doses of a drachm, also combined with rhubarb, and without any ill consequences. Many of the patients to whom I have administered it were labouring under mild diarrhœa. In all cases it has appeared to me to act as a mild and safe purgative; and this, until recently, has been the general property ascribed to it by medical writers.

In 1839, Wibmer[1] stated that, in doses of from half a scruple to a drachm, it operates as a resolvent, and promotes secretion from the alimentary canal; in doses of from two to six drachms, it acts as a purgative, and likewise as a diuretic, promoting all the secretions and excretions, but having a less cooling and more of a stimulating operation than other neutral salts. In larger doses, he adds, it produces abdominal pain, violent diarrhœa, and even inflammation of the stomach and bowels.

More recently[2] attention has been drawn to its poisonous and, in several instances, fatal effects. In one case two ounces, in another about ten drachms in six doses, and in a third 600 grs. in three doses, are stated to have proved fatal. Death is even said to have occurred after, though perhaps not in consequence of, a dose of about thirty grains. Violent, but not fatal, effects have also been observed in other cases. In all the three fatal cases above referred to, the patients were females: in one the sulphate was given to produce abortion; in another, as a laxative after parturition; in the third, to stop the secretion of milk. The symptoms resembled cholera: abdominal pain, vomiting, purging, cramps of the extremities, and great exhaustion. In the second case above referred to, death occurred two hours after taking the sixth dose. In one of the three fatal cases the stomach is said to have been highly inflamed, and blood effused on the brain; in the second case the mucous membrane of the stomach and intestines was found pale, except the valvulæ conniventes, which were reddened; in the third case some appearance of inflammation was observed in the stomach.

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[1] *Die Wirkung der Arzneimittel. und Gifte*, 7tes Heft, München, 1839.

[2] *Pharmaceutical Journal*, vol. iii. p. 256, 1843.

Various causes have been assigned for these violent and fatal effects. The presence of some deleterious ingredient (as arsenic) in the sulphate of potash taken, and the mechanical irritation of the fine spicula of the powder, have been respectively stated as the cause of the death. But neither of these explanations are admissible. In two of the fatal cases the sulphate was carefully analysed, in one of them by Mr. Brande, in the other by M. Chevallier, but no metallic or other deleterious ingredient was detected. The quality of the effects (different from those produced by the ingestion of pounded glass); the rapidity with which death has occurred after its use; the paleness, in one instance, of the alimentary mucous membrane; and the fact that in the case of some other alkaline salts death has equally resulted when these agents were taken in the form of solution,—are reasons for rejecting the hypothesis of mechanical action as the cause of the fatal effects produced by sulphate of potash.

Although in two of the fatal cases inflammation is mentioned as having been observed in the alimentary canal, yet I cannot admit that this was the cause of death. The symptoms produced were rather those of cholera than of inflammation: the death in one case was too rapid to have been the effect of gastro-intestinal inflammation; the mucous membrane is described in one instance as having been pale; and in none of the cases were the inflammatory appearances such as would, in my opinion, account for the symptoms and death.

On the whole, then, I am disposed to believe that the poisonous effects have resulted from the absorption of the salt.

David,[1] Deleurye,[2] and Levret,[3] have ascribed to sulphate of potash the power of repressing the secretion of milk; and their observations have been more recently confirmed by Martin[4] (see *ante*, p. 465).

Uses.—Sulphate of potash has been found serviceable as a mild laxative in disordered conditions of the alimentary canal, as at the commencement of mild diarrhœa, in dyspepsia, hepatic disorders, and hemorrhoidal affections. It is best given in these cases in combination with rhubarb. Thus from five to ten grains of rhubarb with from fifteen grains to a drachm of this salt will be usually found to act mildly and efficiently.

As a lactifuge or represser of the milk, it has been much used by some of the French accoucheurs of the last century, as I have already mentioned. Levret also considered it a valuable purgative in the disorders of childbed, especially puerperal fever.

It has been esteemed an excellent aperient for children. The objections to its employment are its slight solubility, and that when given in large doses to children it is apt to produce vomiting.

It is useful, on account of its hardness and dryness, for triturating and dividing powders, as in the *pulvis ipecacuanhæ compositus*, in which it serves to divide the opium. Its powder, on account of its hardness and solubility, is an excellent dentifrice: the only objection to its use is its taste.

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[1] *Dissertation sur ce qu'il convient faire pour diminuer ou supprimer le Lait des Femmes*, 12mo. Paris, 1763.

[2] *Traité des Accouchemens*, Paris, 1770.

[3] *L'Art des Accouchemens*, 3me éd. Paris, 1766.

[4] *Annalen f. d. gesammte Heilk. in Baden*. 3 Jahrg. H. 2, S. 149.

DOSE.—It is given in doses of from fifteen grains to one or two drachms. It is a constituent of the *pulvis salinus compositus*, E.

POTASSÆ SULPHAS CUM SULPHURE, E.; *Sal Polychrestum Glaseri; Glaser's Sal Polychrest.* (Nitrate of Potash and Sulphur, equal parts; mix them thoroughly; throw the mixture, in small successive portions, into a red-hot crucible; and when the deflagration is over, and the salt has cooled, reduce it to powder, and preserve it in well-closed bottles).—The sulphur is oxidized at the expense of the oxygen of the nitric acid, and the resulting greyish-white compound consists principally of sulphate of potash, mixed probably with some sulphite; but the precise nature of the compound has not been carefully determined. Dr. Christison states that it "is much more soluble than sulphate of potash, and it crystallizes from a state of solution in rhombic prisms—the primitive form of that salt. Both the substance itself and its solution have a sulphureous odour, but sulphuretted hydrogen is not disengaged on a strong acid being added, nor is sulphuret of lead thrown down by the salts of that metal. The salts of baryta cause a white precipitate insoluble in nitric acid, so that sulphate of potash is present."[1] Dr. Duncan[2] says "that in its medical effects and exhibition it agrees with the sulphureous mineral waters, which contain a portion of neutral salt." It is used as a purgative in dyspepsia and chronic skin diseases.—Dose, ℥ss. to ℥j.

2. Potassæ Sesquisulphas.—Sesquisulphate of Potash.

Formula $2KO,3SO^3,HO$. *Equivalent Weight* 223.

This salt is probably a compound of sulphate of potash (KO,SO^3) and the hydrated bisulphate ($KO,2SO^3,HO$); or of two equivalents of sulphate of potash $2(KO,SO^3)$ and one equivalent of sulphate of water (HO,SO^3). The latter view is that of Professor Graham. This salt is a frequent constituent of the salt remaining after the distillation of the nitric acid, and which was formerly called *sal enixum Paracelsi*. It crystallizes in fine, slender, prismatic needles.

3. Potassæ Bisulphas.—Bisulphate of Potash.

Formula $KO,2SO^3$. *Equivalent Weight* 127.

HISTORY.—The mode of preparing this salt was taught by Lowitz and Link at the latter end of the last century. The salt has had various names; such as *supersulphate of potash*, *sal enixum*, *acid vitriolated tartar*, and *sal auri philosophicum*.

PREPARATION.—All the British Colleges give formulæ for the preparation of it.

The *London* and *Edinburgh Colleges* direct it to be prepared by adding sulphuric acid to a solution of the salt which remains after the distillation of [pure, *E.*] nitric acid, boiling down and setting aside the solution that crystals may be formed. The London College uses lbij. of the salt, lbj. of sulphuric acid, and Ovj. of boiling water. The Edinburgh

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[1] Dr. Christison's *Dispensatory*, 2d edit. 1842.

[2] *Edinburgh Dispensatory*.

College employs the same quantity of the salt and water, but only f℥vij. and ʒj. of commercial acid.

The *Dublin College* prepares it from Sulphuric Acid of commerce, two parts; Carbonate of Potash, from Potashes, as much as may be sufficient; Water, six parts. Let one portion of the sulphuric acid, mixed with the water, be saturated by the carbonate of potash; then let another portion of the acid be added to the mixture. Let the liquor evaporate until, on cooling, crystals are formed.

The salt which remains in the retort after the distillation of nitric acid of the London and Edinburgh Pharmacopœias is a bisulphate of potash. If it be dissolved in water, and the solution allowed to crystallize, neutral sulphate is first deposited; and, by further evaporation, some anhydrous bisulphate is obtained. But, by employing a considerable excess of sulphuric acid, the formation of the neutral sulphate is prevented, and bisulphate only is procured. The crystals which first form are acicular and anhydrous; but this anhydrous salt subsequently liquefies, and forms rhomboidal crystals of the hydrous bisulphate. This change occurs the more quickly as the excess of acid is greater.

The process of the Dublin Pharmacopœia yields the neutral sulphate chiefly.

PROPERTIES.—There are two bisulphates of potash—the anhydrous and the hydrous.

α. *Anhydrous bisulphate of potash.*—This appears in acute prisms or acicular crystals, whose sp. gr. is 2·277, and which fuse at 410° F. It may be dissolved and crystallized again from a quantity of hot water not more than sufficient to dissolve it: a larger quantity of water decomposes it. Left in their mother liquor, the crystals disappear, and crystals of the hydrated bisulphate are formed. The anhydrous bisulphate is thus composed:—

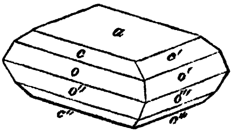
	Atoms.	*Eq. Wt.*	*Per Cent.*	*Jacquelain.*
Potash	1	47	37	37·05
Sulphuric acid	2	80	63	62·95
Anhydrous bisulphate of potash	1	127	100	100·00

β. *Hydrous bisulphate of potash.*—There are probably two hydrous bisulphates—one with a single equivalent of water, and another with two equivalents.

Jacquelain[1] states that the hydrous bisulphate crystallizes partly in rhombohedral prisms, whose sp. gr. is 2·163, and which fuse at 386°·6 Fahr.; and partly in silky filaments formed by the union of the rhombohedral crystals.

According to Mitscherlich,[2] the large crystals obtained out of the watery solution are isomorphous with those of sulphur obtained by slow cooling (see fig. 56, p. 341); while those procured by fusion agree with the crystals of feldspar. Mr. R. Phillips[3] describes the primary form of the crystal of the hydrous bisulphate as a right rhombic prism, having but one cleavage,—namely, parallel to plane *a*,—and being often much flatter than the sketch (fig. 82).

FIG. 82.



Prism of Hydrous Bisulphate of Potash.

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[1] *Ann. de Chim. et de Phys.* t. lxx. p. 311, 1839.

[2] Quoted by L. Gmelin, *Hand. d. Chemie*, t. ii. p. 40, 4te Aufl.

[3] *Translation of the Pharmacopœia.*

Hydrous bisulphate of potash has a very acid taste, reacts strongly as an acid on vegetable colours, and decomposes the carbonates with effervescence. Below 386°·6 F. it is a white crystalline mass. It is very soluble in water, but is partially decomposed by that liquid, and the solution deposits neutral sulphate of potash. By a red heat it is decomposed, and evolves water and sulphuric acid, and is converted into the neutral sulphate.

Characteristics.—The presence of sulphuric acid may be recognised by the chloride of barium (see *ante*, p. 355). When subjected to a red heat, bisulphate of potash loses its water and half of its acid. The residue is the neutral sulphate, the potash of which may be detected by the characters already mentioned for this substance (see *ante*, p. 463).

The bisulphate is distinguished from the neutral sulphate by the difference of crystalline form, by its greater fusibility, greater solubility, its acid taste, and its action on litmus and the alkaline carbonates. The following, according to Jacquelain, are the differences between the sulphates of potash:—

Names.	*Formulæ.*	*Crystalline shape.*	*Sp. gr.*	*Fusibility.*	
1. Neutral sulphate of potash	KO,SO^3	Six-sided prisms	2·4	Cherry-red heat	
2. Anhydrous bisulphate of potash	$KO,2SO^3$	Prisms	2·277	410°·6 F.	Both decomposed by water and alcohol.
3. Hydrous bisulphate of potash	KO,SO^3+HO,SO^3	Rhombohedral prisms	2·163	386° F.	

COMPOSITION.—According to Jacquelain, Graham, and Mitscherlich, the composition of hydrous bisulphate of potash is as follows:—

				JACQUELAIN.	
	Atoms.	*Eq. Wt.*	*Per Cent.*	*Rhomb. Prisms.*	*Silky Filaments.*
Potash	1	47	34·559	34·55	34·56
Sulphuric acid	2	80	58·823	58·48	58·69
Water	1	9	6·618	6·97	6·75
Hydrous bisulphate of potash	1	136	100·000	100·00	100·00

But Geiger, R. Phillips, and Dr. T. Thomson, state that it contains two atoms of water:

				GEIGER.	
	Atoms.	*Eq. Wt.*	*Per Cent.*	*Rhomb. Prism.*	*4 & 6-sided Needles.*
Potash	1	47	32·414	32·53	33·83
Sulphuric acid	2	80	55·172	54·77	55·43
Water	2	18	12·414	12·70	10·74
Hydrous bisulphate potash	1	145	100·000	100·00	100·00

It is probable, therefore, that there are two hydrous bisulphates.

PHYSIOLOGICAL EFFECTS AND USES.—It is rarely used as a medicine. It possesses the combined properties of sulphuric acid and sulphate of potash. The excess of acid renders its local operation that of an astringent. When swallowed it operates as a mild purgative, and may be employed in the same cases as the sulphate, over which it has the advantage of greater solubility. Conjoined with rhubarb it covers the bitter taste of the latter without injuring its medicinal properties. Dr. Barker[1] says it may be used to form a cheap effervescing purgative salt as follows:—73 grains of bisulphate of potash and 72 grains of crystallized carbonate of soda, to be separately dissolved in two ounces of water, and taken in a state of effervescence. In the arts it is used as a substitute for dilute sulphuric acid for cleansing iron and other metallic works.

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[1] *Observations on the Dublin Pharmacopœia*, p. 138, Dublin, 1830.

ADMINISTRATION.—The dose of it is from gr. x. to ʒij. properly diluted.

45. Potassii Chloridum.—Chloride of Potassium.

Formula KCl. *Equivalent Weight* 74·5.

Muriate of potash; Febrifuge or digestive salt of Sylvius (sal digestivum seu febrifugum Sylvii); Regenerated sea salt; Diuretic sal ammoniac (sal ammoniacum diureticum); Potassane.—Employed as a medicine by Sylvius de la Boe in the 17th century. Minute cubical crystals of it have been found in the lava of Vesuvius. It exists, though in minute quantities, in sea water (see *ante*, p. 293), in several mineral waters, in rock salt, and in vegetable and animal fluids (*e. g.* in the juice of flesh and in animal milk). It is obtained as a secondary product in various chemical processes; as in the preparation of spiritus ammoniæ, *L. D.* (see *ante*, p. 435), in the manufacture of tartaric acid, iodine (see *ante*, p. 385), chlorate of potash (see p. 491), soap, glass, &c., and in the refining of saltpetre. It occurs in prismatic, cubical, or octohedral crystals (see *ante*, p. 138). In taste it resembles common salt. While dissolving in water, it produces a much greater degree of cold than chloride of sodium. In its medicinal properties it resembles common salt. It was formerly used in medicine as a diaphoretic, resolvent, and febrifuge; but, of late years, it has almost entirely fallen into disuse. If, however, Dr. Garrod's hypothesis (see *ante*, p. 464) of the cause of scurvy be correct, it might be advantageously mixed with common salt, and used at table as an antiscorbutic. The dose of it is ℈j. to ʒss. or more. Its principal consumption, at the present time, is in the manufacture of alum. It is also occasionally employed as a test for tartaric acid.

46. Potassæ Hypochloris.—Hypochlorite of Potash.

Formula KO,ClO. *Equivalent Weight* 90·5.

A watery solution of hypochlorite of potash and of chloride of potassium constitutes the *Eau de Javelle*, or the *solution of chloride of potash (liquor potassæ chloridi)*, or *chlorinated potash water (aqua potassæ chlorinatæ)*. It is prepared either by passing chlorine gas into carbonate of potash, so as not quite to saturate the alkali (see p. 491); or by decomposing ℥ij. of chloride of lime contained in Oiss. of water, by ℥iv. of carbonate of potash dissolved in Oss. of water, and filtering the mixture. The liquid owes its bleaching and disinfecting properties to the hypochlorite of potash. Its medicinal properties and uses are similar to those of chloride of soda (see *Sodæ Hypochloris*). It is eliminated by the kidneys (see *ante*, p. 102). Some cases of poisoning with it have occurred.[1] It appeared to act as a chemical irritant. Albuminous liquids (white of egg and water, milk, flour and water) are the best antidotes.

47. POTASSÆ CHLORAS.—CHLORATE OF POTASH.

Formula KO,ClO^5. *Equivalent Weight* 122·5.

HISTORY.—Chlorate of potash, formerly called *oxymuriate* or *hyperoxymuriate of potash*, was first obtained, in 1786, by Mr. Higgins,[2] who mistook it for nitrate of potash. In 1786 it was distinguished by Berthollet.

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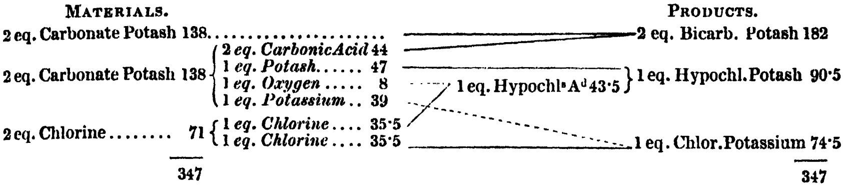
[1] A. S. Taylor, *On Poisons*, p. 284.

[2] *Experiments and Observations relative to Acetous Acid, &c.* Lond. 1786.

PREPARATION.—There are several methods of procuring it:

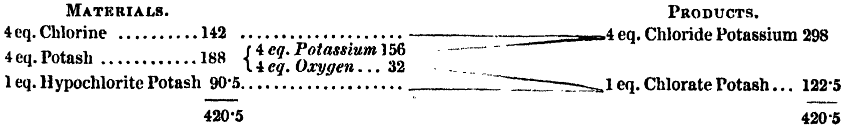
1. By the old method it is prepared by passing chlorine gas slowly through a cold solution of carbonate of potash placed in a Woulfe's bottle. The liquid is allowed to stand for twenty-four hours in a cool place, and is then found to have deposited crystals of chlorate of potash. These are to be drained, washed with cold water, dissolved in hot water, and re-crystallized.

When chlorine gas comes in contact with a solution of carbonate of potash, three salts are formed:—chloride of potassium, hypochlorite of potash, and bicarbonate of potash. $4(KO,CO^2)+2Cl=2(KO,2CO^2)+KO,ClO+KCl$.



In proportion as the quantity of chlorine increases, the bicarbonate becomes decomposed; carbonic acid is evolved, and a further quantity of hypochlorite of potash and chloride of potassium is produced. By the reaction of the carbonic acid on some hypochlorite of potash, a portion of hypochlorous acid is set free, which gives the liquor a yellow tinge.[1]

When the solution is strongly charged with hypochlorite, the action of the chlorine on the potash is somewhat changed: it abstracts the potassium from the potash, and thereby forms chloride of potassium; while the oxygen thus set free combines with some hypochlorite of potash, and thereby converts it into the chlorate, the greater part of which crystallizes. $4Cl+4KO+KOClO=4(KCl)+KO,ClO^5$.


MATERIALS.
PRODUCTS.
4 eq. Chlorine 142
4 eq. Potash 188
4 eq. Potassium 156
4 eq. Oxygen... 32
1 eq. Hypochlorite Potash 90·5
420·5
4 eq. Chloride Potassium 298
1 eq. Chlorate Potash... 122·5
420·5

The residual liquor contains a little chlorate, some free hypochlorous acid, and a considerable quantity of hypochlorite of potash and chloride of potassium.

2. The preceding process is attended with some practical difficulties, to obviate which Professor Graham[2] recommends that carbonate of potash be mixed intimately with an equivalent quantity of dry hydrate of lime, and the mixture exposed to chlorine gas: the products are carbonate of lime, chlorate of potash, and chloride of potassium. $6(KO,CO^2)+6(CaO,HO)+6Cl=6(CaO,CO^2)+5(KCl)+KO,ClO^5$. By the action of water, the chlorate of potash and chloride of potassium are separated from the carbonate of lime, and the chlorate of potash may be crystallized in the usual way.

3. According to Liebig, chlorate of potash is best obtained by dissolving chloride of lime in water, adding to the solution chloride of potassium, and boiling to dryness. The mass is then dissolved in hot water and the solution filtered, if necessary: on cooling, a large quantity of chlorate of potash is deposited. $3(CaO,ClO+CaCl)+KCl=KO,ClO^5+6CaCl$. As the chloride

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[1] Delmar, in *Lond. Edinb. and Dubl. Phil. Mag.* for June 1841, p. 422.

[2] *Proceedings of the Chemical Society*, No. 1.

of lime of commerce contains a variable proportion of lime, it is better to dissolve a known weight of slaked lime in water by passing chlorine through it, by which means the lime is entirely converted into chloride or bleaching compound.

PROPERTIES.—Chlorate of potash crystallizes in nearly rhomboidal plates belonging to the oblique prismatic system. Its taste is cool, and somewhat similar to nitre. When rubbed in the dark, it becomes luminous. 100 parts of water at 32° F. dissolve 3·5 parts of chlorate; at 59° F. 6 parts; at 120° F. 19 parts.

Characteristics.—This salt is known to be a chlorate by the following characters:—When heated, it fuses, gives out oxygen, and is converted into chloride of potassium (see *ante*, p. 266); when thrown on a red-hot coal, it deflagrates—a property, however, common to several other salts. Sulphuric acid gives it an orange-red colour, evolves chlorous acid (peroxide of chlorine), known by its yellow colour and great explosive power when heated. Rubbed with sulphur or phosphorus, it explodes violently. Mixed with hydrochloric acid, and then with water, it forms a bleaching liquid. The base of the salt is known to be potash by the tests for this substance already mentioned (see *ante*, p. 463).

COMPOSITION.—It is an anhydrous salt.

	Atoms.	*Eq. Wt.*	*Per Cent.*	*Berzelius.*
Potash	1	47	38·37	38·4917
Chloric Acid	1	75·5	61·63	61·5083
Chlorate of Potash	1	122·5	100·00	100·0000

IMPURITY.—Chloride of potassium is the usual impurity. This may be detected by a solution of nitrate of silver producing a white precipitate (*chloride of silver*), insoluble in nitric acid, but soluble in ammonia. Pure chlorate of potash undergoes no obvious change on the addition of nitrate of silver to its solution.

PHYSIOLOGICAL EFFECTS. α. *On Animals generally.*—In one series of experiments, Dr. O'Shaughnessy[1] injected from 10 to 60 grains of chlorate of potash, dissolved in three ounces of tepid water, into the cervical vein of a dog: no ill effect was observed; the pulse rose in fulness and frequency, the urine was found in a short time to contain traces of the salt, and the blood of the tracheal veins had a fine scarlet colour. In another series of experiments the animal was stupefied either by hydrocyanic acid or hydrosulphuric acid gas: the brachial vein was opened, and a few drops of excessively dark blood could with difficulty be procured. Half a drachm of the chlorate dissolved in water of the temperature of the blood was injected slowly into the jugular vein: the pulsation of the heart almost immediately began to return, and in the course of eight minutes scarlet blood issued from the divided brachial veins. In twenty minutes the animal was nearly recovered, and passed urine copiously, which was found to contain the chlorate.

β. *On Man.*—The action of this salt on man requires further investigation. It becomes absorbed into the blood (see *ante*, p. 101) and is eliminated by the kidneys (see *ante*, p. 101). It appears to act as a refrigerant and diuretic, like nitrate of potash. By some writers it is denominated resolvent and antiphlogistic. Wöhler and Stehberger recognised it in the urine of patients to whom it had been exhibited; so that it does not appear to undergo any chemical change in its passage through the system. This fact is fatal to the hypothesis of the chemico-physiologists, who fancied that it gave oxygen to the system, and was, therefore, well adapted for patients affected with scorbutic conditions, which were supposed to depend on a deficiency of this principle. Excessive doses of the chlorate, like those of the nitrate, would probably produce an affection of the nervous system; but I am not acquainted with any satisfactory case in proof. Duchateau[1] says that 18 grains taken at thrice caused convulsions and delirium; but the observation is probably erroneous, for others have not experienced these effects from much larger doses. Dr. Stevens[2] says chlorate of potash gives a beautiful arterial colour to the venous blood, and reddens the gums much faster than mercury.

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[1] *Lancet* for 1831-2, vol. i. p. 369.

USES.—Chlorate of potash was originally employed as a medicine for supplying oxygen to the system, where a deficiency of that principle was supposed to exist. With that view it was successfully administered by Dr. Garnett[3] in a case of chronic scorbutus. Dr. Ferriar also tried it in scurvy with success.[4] It was subsequently applied in the venereal disease and liver complaints as a substitute for mercurials, whose beneficial effects were thought to depend on the oxygen which they communicated to the system.[5] It has also been tried in cases of general debility, on account of its supposed tonic effects, but failed in the hands of Dr. Ferriar.[6] In a case of dropsy under the care of the latter gentleman, it operated successfully as a diuretic. More recently, it has been used by Dr. Stevens[7] and others as a remedy for fever, cholera, and other malignant diseases, which, he supposes, depend on a deficiency of saline matters in the blood; but, as it is usually employed in conjunction with common salt and carbonate of soda (see *ante*, p. 181), it is impossible to determine what share the chlorate had in producing the beneficial effects said to have been obtained by what is called the *saline* treatment of these diseases. Köhler[8] tried it in phthisis, without experiencing benefit from it.

It appears, then, that most of the uses of this salt have been founded on certain views of chemical pathology, some of which are now considered untenable. It is very desirable, therefore, that some person, unbiassed by theoretical opinions, would carefully investigate its effects and uses, which I am inclined to think have been much overrated. In a therapeutical point of view it may be regarded as analogous to nitrate of potash; though by some it is considered to hold an intermediate position between nitre and sal ammoniac.

It is sometimes employed in scarlatina and cynanche maligna. Frequently it is administered in conjunction with hydrochloric acid as a source of chlorine (see *Mistura et Gargarisma Chlorinii*, p. 373).

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[1] Mérat and De Lens, *Dict. Mat. Méd.*

[2] *On the Blood*, p. 155.

[3] Duncan's *Annals of Medicine*, 1797.

[4] *Med. Hist. and Reflect.* vol. iii. p. 250.

[5] See the Reports of Mr. Cruikshank and Dr. Wittmann, in Dr. Rollo's *Cases of Diabetes Mellitus*, 2d edit. pp. 504 and 563; also Dr. Chisholm's Letter, in the same work, *Preface*, p. x.

[6] *Op. cit.*

[7] *Op. supra cit.* p. 296.

[8] *Lancet* for 1836-7, vol. i. p. 33

Cotton wool impregnated with a concentrated solution has been employed as a moxa.

Administration.—The usual dose of it is from ten or fifteen grains to half a drachm. Dr. Wittman, in one case, gave 160 grains daily, with a little hydrochloric acid immediately after it, to decompose it. The effects were hot skin; headache; quick, full, and hard pulse; white tongue; and augmentation of urine.

48. POTASSII IODIDUM.—IODIDE OF POTASSIUM.

Formula KI. *Equivalent Weight* 165.

History.—This salt, called also *ioduret of potassium*, and more commonly *hydriodate of potash* (*potassæ hydriodas*), was first employed in medicine by Dr. Coindet.

Natural History.—Iodine and potassium are contained in sea-water as well as in sea-weeds, but it is probable that the iodine is in combination with sodium or magnesium.

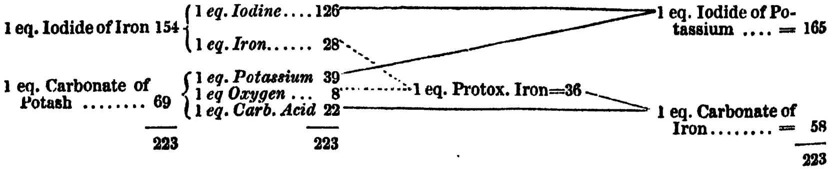
Preparation.—All the British Colleges give directions for the preparation of this salt.

The *London College* orders of Iodine, ʒvj.; Carbonate of Potash, ℥iv.; Iron Filings, ℥ij.; Distilled Water, Ovj. Mix the Iodine with four pints of the Water, and add the Iron, stirring them frequently with a spatula for half an hour. Apply a gentle heat, and, when a greenish colour appears, add four ounces of carbonate of potash, first dissolved in two pints of water, and strain. Wash the residue with two pints of boiling distilled water, and again strain. Let the mixed liquor be evaporated, that crystals may be formed.

The *Edinburgh College* employs of Iodine (dry), ʒv.; Fine Iron-Wire, ℥iij.; Water, Oiv.; Carbonate of Potash (dry), ℥ij. and ʒvj.

The process is much the same as that of the London College, except that the solution of the iodide of potassium is to be concentrated "till a dry salt be obtained, which is to be purified from a little red oxide of iron and other impurities, by dissolving it in less than its own weight of boiling water, or, still better, by boiling it in twice its weight of rectified spirit, filtering the solution, and setting it aside to crystallize. More crystals will be obtained by concentrating and cooling the residual liquor."

The following is the theory of the above processes:—An equivalent of iodine combines with an equivalent of iron, $I + Fe = FeI$. The resulting iodide of iron is decomposed by an equivalent of carbonate of potash, by which one equivalent of iodide of potassium and one of carbonate of iron are obtained. $FeI + KO,CO^2 = KI + FeO,CO^2$.



Prepared by this process,[1] iodide of potassium is apt to be contaminated with carbonate of potash, and it is difficult to get rid of all traces of iron.

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[1] Messrs. Smith propose to use, in the above process, pure carbonate of potash prepared by heating to redness crystallized bicarbonate of potash; and in order to obtain the iodide of potassium free from colour, they fuse it in an iron pot (*Pharmaceutical Journal*, vol. iii. pp. 14 and 80).

The process of the *Dublin College* is as follows:—Take of Iodine, one part; Sulphuret of Iron, reduced to coarse powder, five parts; Sulphuric Acid, seven parts; Distilled Water, forty-eight parts; Water of Carbonate of Potash, a sufficient quantity; Rectified Spirit, six parts. Mix the iodine, by trituration, with sixteen parts of the water, and put the mixture into a glass vessel. Pour the acid, previously diluted with thirty-two parts of water, upon the sulphuret in a matrass, and from a tube, adapted to the neck of the matrass, and reaching to the bottom of the vessel containing the iodine and water, let the gas pass through the mixture until the iodine disappears. Having filtered the liquor, evaporate it without delay, by a superior heat, to one-eighth part, and then filter it again. Then add gradually as much water of carbonate of potash as will be sufficient to saturate the acid, which is known by the cessation of the effervescence. Then expose the mixture to heat until the residual salt is dry and of a white colour; on this pour the spirit, and dissolve it with heat. Lastly, evaporate to dryness the liquor poured off from the residual salt, and preserve the residuum in a well-stoppered vessel.

By the mutual action of sulphuret of iron, water, and sulphuric acid, we obtain, in this process, sulphuretted hydrogen and sulphate of iron (see p. 363). The sulphuretted hydrogen being conveyed into water with which iodine is mixed, a solution of hydriodic acid is obtained, and sulphur is deposited. $HS + I = HI + S$. When the hydriodic acid and carbonate of potash are mixed, mutual reaction occurs, and the products are iodide of potassium, water, and free carbonic acid. $HI + KO,CO^2 = KI + HO + CO^2$.

Another mode of preparing this salt was proposed by the late Dr. Turner. It consists in adding to a hot solution of caustic potash as much iodine as the liquid will dissolve, by which means a reddish-brown fluid is obtained. Then pass hydrosulphuric acid through the liquid until it becomes colourless. Apply a gentle heat, to expel any excess of the acid; filter, to get rid of the free sulphur, and exactly neutralize the free acid present, with potash; then crystallize.

When the potash comes in contact with iodine, two salts are formed—iodide of potassium and iodate of potash. $6I + 6KO = 5KI + KO,IO^5$. The iodate is decomposed by the hydrosulphuric acid, the hydrogen of which forms water, by combining with the oxygen of the iodate; sulphur is precipitated, and iodide of potassium remains in solution. $KO,IO^5 + 6HS = KI + 6HO + 6S$.

Instead of decomposing, by sulphuretted hydrogen, the mixture of iodate of potash and iodide of potassium, it may be subjected to a red heat in a crucible of platinum or iron. The iodate gives out six equivalents of oxygen, and is converted into iodide of potassium. $KO,IO^5 = KI + 6O$. A little iodate is, however, apt to escape decomposition.

Mr. Scanlan informs me, that if powdered charcoal be intermixed with the two salts before they are subjected to heat, the deoxidation of the iodate is easily effected by the carbon.

Iodide of potassium may be obtained by various other processes. Mohr[1] prepares it by converting sulphuret of barium, by means of iodine, into iodide of barium, and decomposing this by sulphate of potash. Another method is to boil lime with iodine, by which iodide of calcium and iodate of lime are formed, and to precipitate the lime by carbonate of potash. The iodate of potash, mixed with the iodide, may be decomposed by heat, or by protoxide of iron.[2]

PROPERTIES.—This salt occurs in white, somewhat shining, transparent, or semi-opaque cubes, or octohedrons, belonging to the regular system. Its taste is acrid saline, somewhat similar to common salt. It fuses at a red heat, and at a high temperature volatilizes unchanged. It decrepitates when heated. Both water and alcohol readily dissolve it: it requires only two-thirds of its weight of water to dissolve it at 60° F. Its aqueous solution dissolves iodine, forming a liquid called *ioduretted iodide of potassium* (*biniodide of potassium*).

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[1] *Pharmaceutical Journal*, vol. v. p. 188.

[2] Mr. R. Phillips, Jun. *Pharmaceutical Journal*, vol. iv. p. 59.

Characteristics.—A solution of this salt is known to contain an *iodide* (see *ante*, p. 386) by the following tests:—

α. A solution of bichloride of mercury occasions a vermilion-red precipitate (*biniodide of mercury*), soluble in excess of iodide of potassium.

β. A solution of acetate of lead produces a yellow precipitate (*iodide of lead*).

γ. A solution of nitrate of silver causes a pale yellow precipitate (*iodide of silver*).

δ. Protonitrate of mercury or calomel occasions a greyish or a greenish yellow precipitate (*protiodide of mercury*).

ε. On the addition of a cold solution of starch and a few drops of nitric acid (or solution of chlorine, or, still better, according to Devergie, a mixture of chlorine and nitric acid), a blue compound (*iodide of starch*) is formed, which is decolorized at a boiling temperature, or by caustic alkali.

ζ. Bichloride of platinum renders the solution brownish red (*biniodide of platinum*).

θ. When oil of vitriol and heat are applied to iodide of potassium a violet-coloured vapour is evolved.

That the base of the salt is *potassium* (see the tests for potash, p. 463) is proved by the following characters:—

α. Perchloric acid occasions a white precipitate (*perchlorate of potash*), while the supernatant liquor becomes yellowish brown, from a little free iodine.

β. Excess of a strong solution of tartaric acid produces a white crystalline precipitate (*bitartrate of potash*).

γ. Carbazotic acid forms yellow needle-like crystals (*carbazotate of potash*).

δ. If a clean pack-thread be soaked in a solution of the iodide, and the wetted end be immersed in melted tallow, and applied to the exterior or blue cone of the flame of a candle, this cone assumes a pale or whitish violet tint.

COMPOSITION.—This salt consists, as its name indicates, of iodine and potassium.

	Atoms.	*Eq. Wt.*	*Per Cent.*	*Gay Lussac.*
Iodine	1	126	76·36	76·2
Potassium	1	39	23·64	23·8
Iodide of Potassium	1	165	100·00	100·0

The crystals contain no water of crystallization.

ADULTERATION.[1]—Iodide of potassium is often largely adulterated with *carbonate of potash*. In 1829 I analyzed a sample which contained 77 per cent. of the latter salt.[2] In one specimen Dr. Christison procured 74·5 per cent. of carbonate of potash, 16 of water, and only 9·5 of iodide of potassium.[3] The impure salt may be distinguished by the absence of a regular crystalline form; by adding a few particles of it to lime-water, a milky fluid (*carbonate of lime*) is obtained, whereas the liquid remains transparent if the iodide be pure; by its destroying the colour of tincture of iodine, whereas the pure salt does not affect it; and lastly, by alcohol, which dissolves iodide of potassium, but not carbonate of potash.

Traces of the chlorides and sulphates are not infrequent in commercial iodide of potassium. To detect the *chlorides*, add nitrate of silver, which precipitates the carbonates, chlorides, and iodides, and digest the precipitate in ammonia, which redissolves the chloride, but not the iodide of silver. On the addition of the nitric acid to the ammoniacal solution, the chloride is thrown down, while the carbonate is converted into nitrate of silver. The *sulphates* may be detected by chloride of barium, which occasions a white precipitate (*sulphate of baryta*), insoluble in nitric acid.

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[1] For some remarks on the method of detecting impurities in iodide of Potassium, see *Pharmaceutical Journal*, vol. ii. p. 533.

[2] *Med. and Phys. Journ.* Sept. 1829.

[3] *Treatise on Poisons*, 3d edit. p. 182.

If iodide of potassium be contaminated with a *bromide*, the latter may be detected as follows:—Add to a solution of the suspected iodide a solution of one part of sulphate of copper and two and a quarter parts of protosulphate of iron: the whole of the iodine is thrown down in the form of protiodide of copper (Cu^2I), but the bromine, as well as any chlorine which may be present, remains in solution. The bromine is then to be detected in the mixed liquid by adding a solution of chlorine (or hydrochloric acid and chloride of lime) and then some sulphuric ether: the chlorine disengages the bromine, which dissolves in the ether, to which it communicates a hyacinth red colour (see *ante*, p. 403).

In the first edition of this work, I mentioned that I had met with a variety of iodide of potassium, which, by keeping, underwent decomposition, evolved an odour of iodine, and became yellow. As it yielded me, on analysis, iodine and potash only, I was unable to account for the changes just referred to. Mr. Scanlan[1] has since explained them, and shown that this variety of iodide of potassium is contaminated with *iodate of potash*, the presence of which has been already accounted for (see *ante*, p. 495). It may be readily detected by adding to a solution of the suspected iodide a solution of tartaric acid. If the iodide be pure, the resulting liquor is at first colourless, but becomes quickly yellow by the action of atmospheric oxygen on the hydriodic acid which is thus generated. If, however, iodate of potash be also present, a quantity of free iodine is instantly developed. This arises from the mutual reaction of the disengaged hydriodic and iodic acids by which water and free iodine are generated. Whether iodate be present or absent, the addition of tartaric acid causes the precipitation of crystals of bitartrate of potash.

Iodide of potassium readily becomes contaminated with *metallic matter* derived from the vessels in which it is crystallized. I have samples of it, in octohedral crystals, which contain traces of lead and tin, derived, I presume, from the metallic vessels in which the salt had been prepared.

Iodide of potassium is sometimes contaminated with a *sulphuretted organic matter* (xanthate of potash?) formed by the employment of spirit of wine and sulphuretted hydrogen, or a metallic sulphuret, in the preparation of the iodide. Iodide thus contaminated has an unpleasant, assafœtida-like odour: it evolves sulphurous acid and becomes greyish-brown when heated; and the residue, treated with water, yields a solution which contains sulphate of potash, as well as iodide of potassium, while a sulphuretted coal remains behind (L. Gmelin).

The following are the characters of pure iodide of potassium according to the *London College*:—

Totally soluble in water and in alcohol. It alters the colour of turmeric either not at all, or very slightly. It does not alter the colour of litmus. Subjected to heat, it loses no weight. Sulphuric acid and starch added together, it becomes blue. Ten grains of this salt are sufficient to decompose 10·24 grains of nitrate of silver: what is precipitated is partly dissolved by nitric acid and partly altered in appearance, which is not the case when ammonia is added.

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[1] *Lancet*, Aug. 29, 1840, p. 816.

The non-action on turmeric proves the absence of alkali (or its carbonate) and acid. If it decompose more than the above quantity of nitrate of silver, the presence of chloride of potassium may be suspected.

The *Edinburgh College* gives the following characters of the pure iodide:—

Its solution is not affected, or is merely rendered hazy, by solution of nitrate of baryta. A solution of five grains, in a fluidounce of distilled water, precipitated by an excess of solution of nitrate of silver, and then agitated in a bottle with a little aqua ammoniæ, yields quickly, by subsidence, a clear supernatant liquor, which is not altered by an excess of nitric acid, or is rendered merely hazy.

The nitrate of baryta forms a white precipitate with either an alkaline carbonate or sulphate. The nitrate of silver is used to detect any chloride.

PHYSIOLOGICAL EFFECTS. α. *On Vegetables.*—The effects of this salt on vegetables have not been ascertained.

β. *On Animals generally.*—The experiments of Devergie[1] on dogs, as well as those of Dr. Cogswell[2] on rabbits, have shown that, to these animals, iodide of potassium is a powerful poison. It operates as a local irritant, and thereby inflames the tissues with which it is placed in contact. Four grains injected into the jugular vein of a dog caused convulsions and death within a minute. Two drachms introduced into the stomach gave rise to vomiting and great depression; the latter increased until death, which occurred on the third day: after death, ecchymosis, ulceration, and redness of the stomach, were observed.[3] Dr. Cogswell injected three drachms of the iodide beneath the skin of the back of a dog: the animal died on the third day. On chemical examination, iodine was detected in the blood from the heart, in the brain and spinal cord, the liver, spleen, stomach, muscles, tongue, and the bones freed from their appendages; likewise in the contents of the bladder.[4]

γ. *On Man.*—Both the physiological effects and therapeutical uses of iodide of potassium shew that its operation is analogous to that of iodine.

The *local action* of iodide of potassium is that of an irritant. It no doubt reacts chemically, but the changes produced have not been investigated (see *ante*, pp. 94, 178, and 182). When taken internally in large doses, it not unfrequently occasions nausea, vomiting, pain and heat of stomach, and purging. Applied to the skin in the form of ointment, it sometimes produces slight redness. It is much less energetic in its action than free iodine; and, therefore, may be given in larger doses, and continued for a longer period, without evincing the same tendency to produce disorder of the stomach and intestinal canal. Lugol[5] found that baths at 100° F., containing three ounces of iodide of potassium, produced temporary itching only; whereas baths at the same temperature, containing ten scruples of iodine, caused prickling, then itching, smarting, punctuated, separated, or confluent rubefaction (which was not commensurate with the itching), and subsequently desquamation of the epidermis. The chemical action of iodide of potassium on the tissues is probably slight, as, indeed, might be expected, seeing that no obvious changes are produced when a solution of this salt is mixed with albumen, fibrin, or gelatine—the three most abundant organic constituents of the animal body.

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[1] *Médecine Légale*, t. ii. p. 536.

[2] *Experimental Essay on Iodine*, Edinb. 1837.

[3] Devergie, *op. cit.* p. 506.

[4] Cogswell, *op. cit.* p. 91.

[5] *Essays on the Effects of Iodine in Scrofulous Diseases*, translated by Dr. O'Shaughnessy, p. 65, Lond. 1831.

Iodide of potassium *becomes absorbed* and is carried out of the system by the different secretions, in which, as well as in the blood, it may be easily detected[1] (see *ante*, pp. 101 and 102). Moreover, it deserves especial notice that it has been found in the urine several days after it has been swallowed.[2] To detect it in the urine, add first starch to the cold secretion, then a few drops of nitric acid (or solution of chlorine), and the blue iodide of starch will be formed if an iodide be present.

Iodine has also been recognised in the liquor amnii of a female, during parturition, who for four months previously had taken the iodide.[3] Landerer[4] detected it in the testicle of a man to whom he had administered it.

The *remote* or *constitutional effects* of iodide of potassium are very analogous to those of iodine. Diuresis is a common consequence of its use. Relaxation of bowels is not infrequent. Occasionally ptyalism has been observed.[5] Dr. Wallace mentions that irritation of throat is produced by it. Atrophy of the mammæ is a very rare effect of it, but a case is mentioned by Mr. Nesse Hill.[6] Wasting of the testicle, also, is said to have resulted from its use.[7] Headache, watchfulness, and other symptoms indicative of the action of this salt on the nervous system, have been noticed by Dr. Clendinning and Dr. Wallace. Increased secretion from, and pain of, the mucous membrane lining the nasal passages have been observed. I have repeatedly remarked, that the pocket-handkerchiefs used by patients who are taking this salt acquire a distinct odour of iodine.

Great discrepancy exists in the statements of authors as to the effects of given doses of iodide of potassium. "The average dose of this medicine," says Dr. Williams,[8] "is eight grains; carried beyond that quantity it purges; and even limited to that quantity, it requires some management to obviate nausea." In two cases mentioned by Dr. Wallace,[9] a drachm of this salt taken in divided doses caused vomiting, colicky pains, slight diarrhœa, frequency of pulse, and exhaustion. Mr. Erichsen has reported a case of extreme irritation of the nasal, conjunctival, and bronchial mucous membrane produced by five grains of the iodide; and Dr. Laurie has known seven and a half grains, given in three doses, cause serious symptoms; and in two cases he thinks death was the consequence of small doses presented medicinally.[10] These statements, then, show that this salt possesses very active properties, and coincide with the experience of many practitioners and with the results obtained from the experiments on animals. But we have, in opposition to the above, the evidence of Dr. Elliotson,[1] of Dr. Buchanan,[2] and, more recently, Payen and Ricord. The first tells us that six drachms may be given daily (in doses of two drachms) for many weeks without inconvenience; and the second states half an ounce may be given at a dose without producing pain of the stomach or bowels, purging, or any hurtful effect. Furthermore, both physicians vouch for the purity of the salt employed. Payen gave sixty grains daily, and Ricord one hundred and thirty-five, without any serious effects.[3] It is difficult to explain such discrepancies. But I cannot help thinking that peculiarities of constitution and morbid conditions of system (especially affections of the stomach) are principally concerned in modifying (either increasing or diminishing) the tolerance to this salt. I do not think that the different effects observed can be wholly ascribed to alterations in the quality or adulterations of the medicine employed, though I have published a case[4] showing that the adulterated is much less active than the pure salt.

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[1] Buchanan, *Lond. Med. Gaz.* vol. xviii. p. 519; Wallace, *Lancet*, for 1835-6, vol. ii. p. 6: the latter authority failed to detect it in the blood.

[2] Christison, *Treatise on Poisons*, 3d edit. p. 185.

[3] *Comptes Rendus*, 1845, t. i. p. 878 (quoted by Mr. A. S. Taylor).

[4] Heller's *Archiv.* 1847 (A. S. Taylor).

[5] Dr. Clendinning, *Lond. Med. Gaz.* vol. xv. p. 869; and Dr. Wallace, *Lancet*, for 1835-6, vol. ii. p. 8.

[6] *Edinb. Med. and Surg. Journ.* vol. xxv. 1826, p. 282.

[7] *Lancet*, Oct. 16, 1841.

[8] *Lond. Med. Gaz.* vol. xiv. p. 42. See also *Lancet*, Oct. 16, 1841.

[9] *Lancet*, for 1835-6, vol. ii. p. 9.

[10] *Lond. Med. Gaz.* vol. xxvi. p. 588.

May not, in some cases, the different effects have depended on the degree of concentration of the solution of the salt? Weak solutions would probably become absorbed; stronger ones fail to do so (see *ante*, p. 92).

Uses.—Having so fully detailed (see *ante*, p. 391 *et seq.*) the uses of iodine, it is unnecessary to notice at any length those of iodide of potassium, since they are for the most part identical. Thus it has been employed in bronchocele, scrofula, in chronic diseases accompanied with induration and enlargement of various organs, in leucorrhœa, secondary syphilis, periostitis, articular rheumatism, dropsies, &c. As a remedy for the hard periosteal node brought on by syphilis, it was first employed by Dr. Williams,[5] who obtained with it uniform success. At the end of from five to ten days its mitigating effects are felt; the pains are relieved, the node begins to subside, and in the majority of cases disappears altogether. In these cases Dr. Clendinning[6] has also borne testimony to its efficacy. In the tubercular forms of venereal eruptions Dr. Williams found it beneficial. In Dr. Wallace's lectures[7] are some valuable observations on the use of iodide of potassium in venereal diseases. In chronic rheumatism accompanied with alteration in the condition of the textures of the joint, it is, in some cases, remarkably successful.[8] As an ingredient for baths, Lugol[9] found the iodide would not answer alone, but that it was useful as a solvent means for iodine.

Administration.—Iodide of potassium may be employed alone or in conjunction with iodine, forming what is called ioduretted iodide of potassium. *Internally* it has been given alone in doses varying from three grains to half an ounce (see *ante*, p. 499). To be beneficial, some think it should be given in small, others in large doses. Not having had any experience of the effects of the enormous doses before referred to, I can offer no opinion thereon. The usual dose which I am in the habit of giving to adults is five grains. It may be administered dissolved in simple or medicated water, or in some bitter infusion. It is frequently administered in combination with iodine.

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[1] *Lancet*, vol. i. 1831-2, p. 728.

[2] *Lond. Med. Gaz.* vol. xviii. p. 519.

[3] Mr. A. S. Taylor, *On Poisons*, p. 827.

[4] *Lond. Med. Gaz.* vol. xvii. p. 839.

[5] *Ibid.* vol. xiv. p. 42.

[6] *Ibid.* vol. xv. p. 833.

[7] *Lancet*, for 1835-6, vol. ii.; and for 1836-7, vols. i. and ii.

[8] Dr. Clendinning, *Lond. Med. Gaz.* vol. xv. p. 866; and Dr. Macleod, *Lond. Med. Gaz.* vol. xxi. p. 361.

[9] *Essays*, p. 75.

ANTIDOTES.—No chemical antidote is known. In a case of poisoning, therefore, the first object will be to evacuate the contents of the stomach, exhibit demulcent and emollient drinks, combat the inflammation by the usual antiphlogistic measures, and appease the pain by opiates.

1. **UNGUENTUM POTASSII IODIDI**; *Unguentum Potassæ Hydriodatis*, D.; *Ointment of Iodide of Potassium.* (Iodide of Potassium, ℈j.; Prepared Hog's-Lard, ℥j. Mix.)—In the preparation of this ointment two advantages are gained by dissolving the iodide in water previous to its admixture with the lard:—it obviates the inconvenience of the small particles of iodide irritating the skin, and it facilitates the absorption of the salt. The weight of water required is somewhat less than that of the iodide employed. —It is to be regretted that neither the London nor Edinburgh Pharmacopœias contain a formula for this ointment. By keeping, this ointment is apt to acquire a yellowish colour, obviously from a little iodine being set free. In some cases this may depend on the iodine being contaminated with a little iodate of potash. It usually, however, arises from the action of the fatty acid (contained in the rancid fat) on the potassium of the iodide. If spermaceti ointment be substituted for lard, the change is more speedy. Mr. Bell[1] thinks this arises from the wax (used in preparing the ointment) having been bleached with chlorine, of which a trace is retained by it; and thus a minute portion of iodine is liberated. When pure and fresh made, this ointment does not stain the skin like the compound ointment of iodine. Its strength should be twice or thrice that of the Dublin preparation. Messrs. Smith,[2] of Edinburgh, have proposed an ointment containing a drachm of iodide and a drachm of water to an ounce of lard.

2. **UNGUENTUM IODINII COMPOSITUM**, L.; *Unguentum Iodinei*, E.; *Compound Ointment of Iodine; Ointment of Ioduretted Iodide of Potassium.* (Iodine, ʒss.; Iodide of Potassium, ʒj.; Rectified Spirit, fʒj.; Lard, ℥ij.; First rub the iodine and iodide of potassium with the spirit, then mix with the lard, *L.*—The *Edinburgh College* omits the spirit, but uses the same proportions of the other ingredients.)—This ointment is employed in bronchocele, enlargement of the lymphatic glands, &c.

3. **TINCTURA IODINII COMPOSITA**, L.; *Compound Tincture of Iodine.* (Iodine, ℥j.; Iodide of Potassium, ℥ij.; Rectified spirit, Oij. Macerate until they are dissolved, and strain.)—This solution may be mixed with water without any deposition of iodine. The dose at the commencement is ♏x., which may be gradually increased to fʒj. or more. When wine is admissible, sherry is a good vehicle for its exhibition.

4. **LIQUOR POTASSII IODIDI COMPOSITUS**, L.; *Compound Solution of Iodide of Potassium; Solution of Ioduretted Iodide of Potassium.* (Iodide of Potassium, grs. x.; Iodine, grs. v.; Distilled Water, Oj. Mix, that they may be dissolved.)—It is a brown-coloured solution, having the

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[1] *Pharmaceutical Journal*, vol. iv. p. 310.

[2] *Ibid.* vol. iii. p. 545.

peculiar smell and taste of iodine. It may be diluted with water without suffering any change. It may be usefully employed in the diseases of children.—Dose for adults, from f℥ij. to f℥vj., or even beyond this. One fluidounce of this solution contains only half a grain of iodide of potassium and a quarter of a grain of iodine.

The *liquor iodinei compositus*, Ph. Ed. consists of Iodine, ʒij.; Iodide of Potassium, ℥j.; Distilled Water, f℥xvj. Dissolve the iodide and iodine in the water with gentle heat and agitation.—This preparation, therefore, though agreeing in the nature of its ingredients with the *liquor potassii iodidi compositus*, Ph. L. differs very considerably in its strength. A fluidounce of it contains thirty grains of iodide of potassium and seven grains and a half of iodine: so that it contains sixty times as much iodide of potassium, and thirty times as much iodine as the corresponding preparation of the London Pharmacopœia.—Dose, ♏x. to ♏xv.

5. SOLUTIONES POTASSII SUPERIODIDI; *Solutions of Superiodide of Potassium; Solutions of Ioduretted Iodide of Potassium.*—Solutions of ioduretted iodide of potassium, of various strengths, have been employed for different purposes by Lugol.[1] The following are the most important:—

α. Lugol's Concentrated Solution of Iodine in Iodide of Potassium consists of Iodine, ℈j.; Iodide of Potassium, ℈ij.; Distilled Water, ℥vij. Mixed with 3 pints and 13 fluidounces of water, it forms a solution equal in strength to the *Liquor Potassii Iodidi compositus*, L.

β. Lugol's Ioduretted Mineral Water is prepared of three degrees of strength:—

	No. 1.		No. 2.		No. 3.
Iodine	gr. ¾	....	i.	....	i¼
Iodide of Potassium	gr. i½	....	ii.	....	ii½
Distilled Water	℥viii.	....	℥viii.	....	℥viii.

The solutions are yellowish or orange-coloured, and are quite transparent. When sweetened, they are readily taken by children; but the sugar should be added at the time of administration, as in the course of a few hours it effects a chemical change in the solutions. From six to eight ounces should be taken daily.

γ. Lugol's Caustic, Rubefacient, and Stimulant Solutions are composed of the same ingredients, but in different proportions.

	Stimulating Washes.			Rubefacient Solution.	Caustic Solution.
	No. 1.	No. 2.	No. 3.		
Iodine	gr. ii.	gr. iii.	gr. iv.	ʒiv.	℥i.
Iodide of Potassium	gr. iv.	gr. vi.	gr. viii.	℥i.	℥i.
Distilled Water	lb. i.	lb. i.	lb. i.	℥vi.	℥ii.

Lugol uses the stimulating washes in scrofulous ulcers, ophthalmia, fistulous abscesses, &c. When the scrofulous surfaces require stronger excitement than usual, he employs the rubefacient solution. In tubercular tumors which have obstinately resisted all other forms of treatment, the rubefacient solution may be applied in admixture with linseed meal (forming the *ioduretted cataplasm* of Lugol). To prepare the mixture, the poultice is first made in the ordinary manner; and when moderately cool, a sufficient quantity of the rubefacient liquid is poured on it with a wooden measure. The caustic solution is used for touching the eyelids and nasal fossæ, to repress excessive granulations (see also *Embrocatio Iodinii*, p. 397).

6. BALNEUM POTASSII SUPERIODIDI; *Bath of Superiodide of Potas-*

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[1] Lugol's *Essays on the Effects of Iodine in Scrofulous Diseases*, translated by Dr. O'Shaughnessy, p. 167, Lond. 1831.

sium; Ioduretted Bath.—Lugol employed baths of this kind in the treatment of scrofula. They should be made in wooden vessels.

IODURETTED BATHS FOR CHILDREN.				IODURETTED BATHS FOR ADULTS.			
Age.	Water.	Iodine.	Iodide of Potassium.	Degree.	Water.	Iodine.	Iodide of Potassium.
	(Quarts)	(Troy Grs.)	(Troy Grs.)		(Qrts.)	(Drachms Troy)	(Drachms Troy)
4 to 7	36	30 to 36	60 to 72	No. 1	200	2 to 2½	4 to 5
7 to 11	75	48...60...72	96...120...144	No. 2	240	2...2½...3	4...5...6
11 to 14	125	72...96	144...192	No. 3	300	3...3½	6...7

7. EMPLASTRUM POTASSII SUPERIODIDI. See *Emplastrum Iodinii*, p. 398.

49. POTASSII BROMIDUM.—BROMIDE OF POTASSIUM.

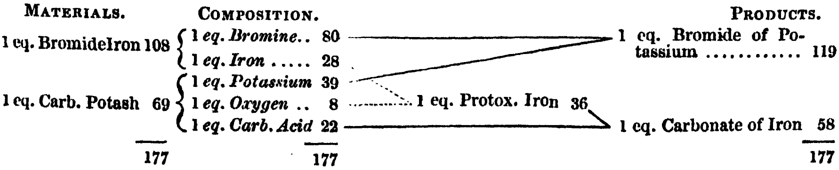
Formula KBr. *Equivalent Weight* 119.

HISTORY.—This salt, also called *hydrobromate of potash*, was first described by Balard in 1826.[1]

PREPARATION.—The *London College* directs it to be prepared as follows:—

Take of Bromine, ℥ij.; Carbonate of Potash, ℥ij. and ʒj.; Iron Filings, ʒj.; Distilled Water, Oiij. First add the iron, and afterwards the bromine, to a pint and a half of the distilled water. Set them by for half an hour, frequently stirring with a spatula. Apply a gentle heat, and when a greenish colour occurs, pour in the carbonate of potash, dissolved in a pint and a half of water. Strain and wash what remains in two pints of boiling distilled water, and again strain. Let the mixed liquors be evaporated, so that crystals may be formed.

In this process bromide of iron is first formed, $Br+Fe=FeBr$: this is afterwards decomposed by carbonate of potash, by which protocarbonate of iron and bromide of potassium are produced. $FeBr+KO,CO^2=KBr+FeO,CO^2$.



Another mode of procuring this salt is to mix bromine with a solution of caustic potash, by which bromide of potassium and bromate of potash are formed. The bromate of potash may be converted into bromide of potassium by heat or by hydrosulphuric acid (see *Iodide of Potassium*, p. 495).

PROPERTIES.—This salt crystallizes in whitish transparent cubes or rectangular prisms. It is inodorous; its taste is pungent, saline, and similar to common salt, but more acrid. It is permanent in the air. When heated it decrepitates, and at a red heat fuses without suffering decomposition. It is very soluble in both cold and hot water, and slightly so in alcohol.

Characteristics.—That this salt is a *bromide* is known by the characters before mentioned (see *ante*, p. 403) for this class of salts. That its base is potassium (or potash) is shown by the tests already given for this substance (see *ante*, pp. 493 and 496).

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[1] *Ann. de Chim. et de Phys.* xxxii.

Composition.—This salt consists of bromine and potassium in the following proportions:—

	Atoms.	*Eq. Wt.*	*Per Cent.*	*Liebig.*	*Balard.*
Bromine	1	80	67·22	67·42	65·56
Potassium	1	39	32·78	32·58	34·44
Bromide of Potassium	1	119	100·00	100·00	100·00

The crystals may contain water lodged mechanically between their plates, but no combined water (water of crystallization).

Purity.—The purity and goodness of this salt may be known by the following characters:—The form of the crystals, their freedom from colour, and their neutrality with respect to litmus and turmeric. A solution of this salt should give no precipitate with chloride of barium, showing the absence of carbonates and sulphates. The method employed by Rose[1] for detecting minute quantities of the chlorides in bromides, is the following:—If pure bromide of potassium, mixed with excess of bichromate of potash, be distilled with concentrated sulphuric acid in a tubulated retort, to which is adapted a receiver containing excess of solution of caustic ammonia, pure bromine distils over, and the ammoniacal liquor, which contains only hydrobromate of ammonia, remains perfectly colourless. But if the bromide contained a chloride, both bromine and the chlorate of the chloride of chromium distil over, and the ammoniacal liquor becomes yellow, owing to the presence of some chromate of ammonia: chromic acid may be detected in the solution by the usual tests.

Commercial bromide of potassium frequently contains iodide of potassium. I detected it in bromide, the produce of the iodine works of Normandy. To recognise the iodide, place some crystals of the suspected bromide on a plate with some solution of starch, and cautiously add a minute portion of diluted nitric acid: the blue iodide of starch is produced. If much nitric acid be employed, the blue colour disappears, owing to the evolution of bromine and the formation of bromide of iodine, which does not act on starch. Lassaigne[2] used chlorine instead of nitric acid. He states that though bromide of iodine does not act on starch paper, yet that if the paper be exposed to the air, the wetted part becomes successively red, violet, and blue; the organic matter of the paper probably decomposing the bromide of iodine and enabling the iodine to act on the starch.

The characters of good bromide of potassium are, according to the London College, as follows:—

> Totally dissolved by water. It does not alter the colours of litmus or turmeric. Chloride of barium throws down nothing from the solution. Sulphuric acid and starch added together render it yellow. Subjected to heat, it loses no weight. Ten grains of this salt are capable of acting upon 14·28 grains of nitrate of silver, and precipitating a yellowish bromide of silver, which is dissolved by ammonia, and but very little by nitric acid.

If more nitrate of silver than the quantity above stated be decomposed by the bromide, the presence of a chloride may be suspected.

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[1] *Journ. de Pharm.* t. xxiii. p. 489.

[2] *Pharmaceutical Journal,* vol. ii. p. 363.

PHYSIOLOGICAL EFFECTS. α. *On Vegetables.*—The effects on plants have not been ascertained.

β. *On Animals.*—Thirteen grains of bromide of potassium dissolved in water, and injected into the jugular vein of a dog, coagulated the blood, caused convulsions and death, in a few minutes.[1] The same experimenter introduced a drachm of the salt into the stomach of a dog without any ill effects, save vomiting. But two drachms, and even a drachm and a half, killed dogs in three days, when retained in the stomach by a ligature of the gullet, with marks of inflammation in the gastro-intestinal membrane. Maillet[2] gave two ounces to a dog without any ill effect; and he observes that, according to the principle that the dose of a saline substance for the horse should be eight times that for the dog, a pound of bromide of potassium would have no ill effect on horses.

γ. *On Man.*—The effects of bromide of potassium on man require further investigation. They appear to be analogous to those of iodide of potassium. Dr. Williams[3] gave five grains of this salt three times daily for fourteen months, without any injurious effect. I gave the same dose to a boy of about 14 years old, affected with enlarged spleen, consequent on intermittent fever, for several weeks, without any marked effect. By the application of starch and a few drops of chlorine to the urine, a yellow bromide of starch was obtained, showing the presence of a bromide in the urine. The boy derived but little benefit from the treatment.

In most cases it acts as a diuretic. In irritable conditions of the alimentary tube it is apt to occasion diarrhœa. Three cases are mentioned by Dr. Williams, in which, on account of this state of the bowels, more than four or five grains could not be exhibited at a time, and even then it was occasionally necessary to give opium. Under the continued use of it, enlargements of the spleen and liver, and swellings of the lymphatic glands, have disappeared; so that it appears to agree with iodine, mercury, and the alkalies, in being liquefacient and resolvent (see *ante*, p. 182). Dr. Williams thinks that it possesses "unusual, if not specific, powers in the cure of diseases of the spleen."

USES.—In 1828, Pourché[4] employed this salt with benefit in the treatment of bronchocele and scrofula: it was taken internally, and applied externally in the form of ointment. In 1836 it was introduced into the London Pharmacopœia, in consequence of the great success obtained from the use of it in a case of enlarged spleen under the care of Dr. Williams.[5] In this, and in three other successful cases of the same disease, it was used internally only. Dr. Williams also gave it with success in a case of ascites. Magendie[6] employs it as an anti-scrofulous remedy, as an emmenagogue, and against hypertrophy of the ventricles. Prieger[7] applied it externally in the form of ointment in tinea capitis.

ADMINISTRATION.—It is exhibited in the form of pill or solution in doses of from four to ten grains three times a day.

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[1] Barthez, *Journ. de Chim Méd.* t. v. p. 214.
[2] *Journ. de Chim. Méd.* t. iii. 2e sér. p. 225.
[3] *Elements of Medicine*, vol. i. p. 338.
[4] *Journ. de Chim. Méd.* t. iv. p. 594.
[5] *Op. cit.*
[6] *Formulaire*, 8me édit. 1835.
[7] Dierbach, *Die neusten Entdeck. in der Mat. Med.* 1837.

ANTIDOTES.—In a case of poisoning by this salt the treatment will be the same as for iodide of potassium.

UNGUENTUM POTASSII BROMIDI; *Ointment of Bromide of Potassium.*—This is composed of from ℈j. to ʒij. of bromide to ℥j. of lard. Bromine is sometimes added.

50. POTASSÆ NITRAS.—NITRATE OF POTASH.

Formula KO,NO^5. *Equivalent Weight* 101.

HISTORY.—At what time this salt became known is difficult now to determine. As it is found in various parts of the East, on the surface of the earth, it appears probable that it must have been known at a very early period. Furthermore, if the Chinese and Hindoos were acquainted with the art of making gunpowder and fireworks at a very early period of history, they must have employed, and, therefore, been acquainted with, nitre. Geber,[1] however, is the first who distinctly mentions it. He describes the mode of making nitric acid from it. But the terms *neter* of the Old Testament,[2] translated *nitre,*—*νίτρον* (Attice, *λίτρον*) of Herodotus[3] and Theophrastus[4]—and *nitrum* of Pliny,[5] appear to have been applied to *natron*.[6] It is probable, however, that the ancients also included under this name nitre (likewise nitrate of lime, according to Harless[7]), which they confounded with carbonate of soda. The term *aphronitrum* (ἀφρονίτρον), or *aphrolitrum* (ἀφρολίτρον), was applied to the softer and more spongy sorts of nitrum; while the phrases *spuma nitri* and *flos nitri* were applied to the nitrum in a superficial or efflorescent form.[8]

The word *saltpetre,* usually applied to nitre, is evidently derived from *sal petræ,* literally signifying rock salt.[9] It is sometimes used in a general sense to signify a nitrate used in the arts; and the particular kind intended to be designated is then distinguished by the name of the base or by the shape of the crystal: and thus nitrate of potash is sometimes called *potash-saltpetre* or *prismatic nitre,* to distinguish it from *soda-saltpetre,* also termed *cubic nitre.* When, however, the word *saltpetre* is used alone, it is understood to mean nitrate of potash.

NATURAL HISTORY.—This salt occurs in both kingdoms of nature.

a. IN THE INORGANISED KINGDOM.—In the East Indies, Egypt, Persia, Spain, and other parts of the world, but especially in warm countries, large quantities of nitre are found in the soil. It would appear to be formed below, and to be brought to the surface of the soil by efflorescence. It is found either disseminated throughout the soil or as an incrustation upon the surface, but not in distinct layers like nitrate of soda in Peru. It has been usually supposed that the nitric acid was formed by the direct union of the nitrogen and oxygen of the air; but there are no facts which justify this opinion. It is much more probable that it is formed by the oxidation of ammonia (which is a constant constituent of the atmosphere); the products being nitric acid and water: $NH^3 + 8O = 3HO + NO^5$. The simultaneous oxidation of hydrogen is necessary to effect the union of oxygen with nitrogen. The cause of this is, that the acid and water unite, so that water may be said to be a condition of *nitrification.*[1] Azotised animal or vegetable matter is no further necessary than as yielding ammonia.[2] In a nitre-cave in Ceylon, Dr. Davy[3] found nitre without animal matter. The potash of the nitrate is in most cases easily accounted for, being found in some of the constituents of the soil, as feldspar and mica. "It must not be forgotten, that the occurrence of saltpetre may sometimes be the result of a process long since finished; and for this reason its formation will appear inexplicable, as it is no longer going on at present, and the conditions which gave rise to it have long ceased to exist," (Knapp).

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[1] *Invention of Verity*, ch. xxiii.

[2] *Proverbs*, ch. xxv. 20; *Jeremiah*, ch. ii. 22.

[3] Book ii. (*Euterpe*), chap. lxxxvii.

[4] *De Igne.*

[5] *Hist. Nat.* xxx. i.

[6] See Beckmann's *History of Inventions and Discoveries*, vol. iv.

[7] *Janus*, Bd. i. S. 454, Breslau, 1846.

[8] Paulus Ægineta, by Adams, vol. iii. pp. 62, 63, and 231.

[9] See *Sodæ Carbonas* and *Sodæ Sesquicarbonas*.

β. IN THE ORGANISED KINGDOM.—This salt has been found in various plants. It is found in tobacco, the sunflower, goosefoot, borage, the nettle, barley, *Cissampelos Pareira*, *Geum urbanum*, &c.[4]

PRODUCTION.—The nitrate of potash employed in this country is obtained by the purification of the native nitre of India; but in some parts of the world it is procured by the purification of what is commonly called artificial nitre—that is, nitre obtained by cultivation. With few exceptions, the localities which naturally afford nitre are within the tropics; while the production of this salt in the temperate zones is effected chiefly by the intervention of man.

1. *From native nitre.*—The district of Tirhût, in Bengal, is more productive of nitre than any other place in India. It is most abundant in those parts containing a redundancy of carbonate of lime. An average sample of the soil analysed by Mr. Stevenson[5] gave the following composition:—

Matter insoluble in three Mineral Acids ...	Silex	50·0
Matter soluble in ditto	Carbonate of Lime...............	44·3
Matter soluble in Water	Sulphate of Soda	2·7
	Muriate of ditto....................	1·4
	Nitrate of Lime....................	0·9
	Nitrate of Potash	0.7
		100·0

Extraction.—"In the month of November, the *leonahs*, or native manufacturers of saltpetre, commence their operations, by scraping off the surface from old mud heaps, mud buildings, waste grounds, &c. where the saltpetre has developed itself in a thin white efflorescence, resembling frost rind. This saline earth being collected at the factories, the operator first subjects it to the process of solution and filtration. This is effected by a large mud filter, lined on the inside with stiff clay." It has a false bottom of bamboo, covered with close wrought grass mats, on which are placed vegetable ashes. Upon these the nitrous earth is laid. Water is then added to dissolve the saline matters of the earth, and the solution thus obtained, filtering through the mats, drops into the empty space between the real and false bottom, and is conveyed away into an earthen receiver. In its passage through the wood-ashes, the carbonate of potash contained in the latter reacts on the nitrate of lime of the solution, and produces nitrate of potash and carbonate of lime. The solution is afterwards evaporated in earthen pots, filtered, and put aside to crystallize. The impure nitre thus procured is termed *dhouah:* it contains from 45 to 70 per cent. of pure nitrate of potash. It is redissolved and crystallized by the native merchants, who supply the Calcutta bazaars; and when thus purified is called by the natives *kalmee.*[1]

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[1] Liebig, *Organic Chemistry in its Application to Agriculture and Physiology*, edited by L. Playfair, Lond. 1840.

[2] "Supposing even that no loss occurs, 260 to 866lbs. of human excrement, 433lbs. of urine, 2600lbs. of cow-dung, or 1024lbs. of fresh muscle, are necessary to supply the nitrogen of 100lbs. of saltpetre," (Knapp's *Chemical Technology*, p. 358).

[3] *Account of the Interior of Ceylon.*

[4] De Candolle, *Phys. Végét.* p. 387; Johnstone's *Lectures on Agricultural Chemistry*, 2d edit. p. 114.

[5] *Journ. of the Asiatic Society of Bengal*, vol. ii. p. 23.

Rough nitre.—Saltpetre is imported into this country principally from Calcutta, but some also comes from Madras. It is brought over in cloth bags, which contain from 150 to 175 lbs. each. Its quality varies considerably. It is always more or less impure: but the common varieties, which have a dirty yellowish appearance, are termed *rough* or *crude saltpetre,* or *grough petre;* while the purer and cleaner looking kinds are called *East India refined.* The loss which it suffers in refining—or, in other words, the impurities which it contains—are technically designated *refraction.* This varies greatly in different samples, but is usually between 5 and 15 per cent.

Estimate of the purity of rough nitre.—The degree of impurity or refraction of the rough nitre imported into this country is approximatively determined previous to sale, in order to enable the merchant or broker to estimate its value. Riffaut's humid method of analysis consists in washing the rough nitre with a saturated solution of pure nitrate of potash: this dissolves the chlorides and leaves the nitre, which is dried and weighed. From this 2 per cent. must be deducted for the nitre deposited from the solution whilst taking up the chlorides. Gay-Lussac's method consists in converting the nitrate into carbonate of potash, by fusing it with charcoal and (to moderate the reaction) with common salt, and estimating the quantity of alkali present. Another method is to dry the salt, by which the amount of water present is estimated; to dissolve in water, and thereby to estimate the quantity of insoluble substances; to test the solution with nitrate of silver, nitrate of baryta, and oxalate of ammonia, in order to form a general action of the impurities; and lastly, to crystallize the soluble salts: the experienced eye readily detects the foreign salts present, such as nitrate of soda, sulphate of potash, sulphate and nitrate of lime, and chlorides of potassium, sodium, and calcium. Husz's physical method has been introduced by him into Austria: it consists in ascertaining the temperature at which a cooling solution of nitre begins to deposit crystals: this is fixed, and depends on the relative proportion of water to that of the nitre dissolved, whether chlorides are present or not. Gossart's method consists in estimating the quantity of nitre and sulphuric acid required to peroxidize a protosalt of iron.[2] In Sweden the fracture of the salt, which has been melted, is employed as the test: pure saltpetre has a coarsely fibrous texture, and is very translucent.

Purification (*Refining process*).—Refined rough nitre is purified by dissolving it in water, boiling the solution, removing the scum, and, after the liquid has been allowed to settle, straining it while hot through a hempen cloth, and setting aside to crystallize. At the Waltham Abbey powder-mills the crystallization is effected in copper pans. When it has been dissolved and crystallized once only it is called *singly refined nitre;* when twice, *doubly*

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[1] See Stevenson, *op. cit.;* also *India Journal of Med. and Phys. Science,* new series, vol. i. p. 10, 1836.

[2] For further details, consult Dumas, *Traité de Chimie,* t. 2me, p. 762; Brande's *Manual of Chemistry;* and Knapp's *Chemical Technology.*

refined[1] (*nitrum depuratum*). Its purity may be ascertained by testing it with nitrate of silver, chloride of barium, and oxalate of ammonia. The first detects the chlorides, the second the sulphates, and the third the calcareous salts (see *ante*, pp. 355 and 369).

The *Dublin College* orders *purified nitrate of potash* (*potassæ nitras purificatum*) to be thus prepared:—Take of Nitrate of Potash, *one part*. Dissolve in two parts of hot water, filter the liquor, and set it aside, that, on cooling, crystals may be formed.

2. *Cultivated* or *artificial nitre.*—In several parts of Europe nitre is cultivated; that is, the conditions necessary to its formation are fulfilled by the intervention of man. Hence, in such cases, nitre is said to be artificially produced; and the places where these operations are carried on are called *artificial nitraria* (*nitrières artificielles*[2]), or sometimes *saltpetre plantations*. The conditions to be fulfilled are the following:—

1. The presence of bases,—viz. lime, magnesia, and potash,—in a loose porous state; as marl, chalk, mortar, &c.
2. The presence of moisture.
3. A temperature of from 59° F. to 68° F.
4. Access of atmospheric air.
5. The presence of decaying organic nitrogenized matters.

Light, perhaps, favours the process; though, in Sweden, it is excluded.

The mode of procedure for fulfilling these indications is modified in different places according to circumstances.

At Appenzel, a canton in Switzerland, nitre is formed from the urine of animals. A hole is dug near to stables, and in this is put a sandy kind of earth, which is kept moistened with the water running from the stables. In two or three years this earth yield's nitre.

In Sweden,[3] where each landed proprietor is compelled to furnish a certain quantity of nitre, it is prepared as follows:—Decomposing animal and vegetable matters, mixed with cinders, lime, or marl, are placed in heaps (called *nitre beds*) under cover, the mass being occasionally moved, or holes made in it, so that they are exposed to the air. From time to time they are watered with urine. At the end of two or three years the nitrogen has combined with oxygen, and this with bases to form nitrates. By lixiviation the salts may be separated, and any nitrate of lime present may be converted into nitrate of potash by adding wood-ashes, which contain carbonate of potash.

In Prussia, *nitre walls* are employed instead of nitre beds; that is, the heaps are made with perpendicular sides like walls. These have two advantages,—they economize land, and they expose a large surface to the air.[4]

At Longpont, in France, a stone quarry is used as a nitre plantation, earth and dung being arranged in alternate layers, and the liquid manure from stables and houses being added to it. Thouvenal proposed the formation of *sheepfold-nitraria* (*nitrières-bergeries*), so that the manure of sheep might be used for nitrification.

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[1] Colonel Moody informed me that the rough nitre supplied to the Waltham Abbey powder-mills has about 3 per cent. refraction, and requires one crystallization only to render it sufficiently pure for the manufacture of gun-powder.

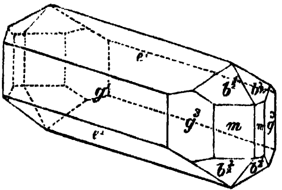
[2] For full details of this process, consult Thénard, *Traité de Chimie*, t. iii. p. 239, 5me éd. Paris, 1827; Dumas, *op. supra cit.*; Kuhlmann, *Mém. Acad. Sciences de Lille*, 1838, and in Liebig's *Annalen*, xxix. p. 272; and Knapp's *Chemical Technology*.

[3] Berzelius, *Traité de Chimie*, t. iii. p. 391.

[4] Dumas, *op. cit.*

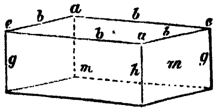
The mode of extracting the nitre from the ripe earth may be easily understood. The earth is lixiviated, the crude lye boiled down, some potash salt added to decompose the nitrates of lime and magnesia and convert them into nitrate of potash, the clear liquid boiled down, and the crude saltpetre allowed to crystallize. In the subsequent refining process, glue is added to the lye to cause the separation of the extractive matter.

FIG. 83.



Crystals of Nitre.

FIG. 84.



Primitive right rhombic prism.

PROPERTIES.—Nitrate of potash usually crystallizes in the form of a six-sided prism with dihedral summits, which belongs to the right prismatic system.[1] Hence this salt is frequently called *prismatic nitre* (*nitrum prismaticum*). It has, therefore, two axes of double refraction, and presents a double system of rings in polarized light (see figs. 33 and 34, p. 141). But sometimes, though rarely, it crystallizes in obtuse rhombohedra; so that it is dimorphous. When pure the crystals are transparent and colourless, have a sharp cooling taste, and undergo no change by exposure to the air. The crystals frequently have a portion of the mother liquor mechanically lodged in spaces in the crystals: hence dry nitre will sometimes yield a moist powder in consequence of the escape of the liquor in the process of pulverization. When heated, this water is expelled, the nitrate of potash fuses, and when cast in moulds forms the *nitrum tabulatum*, or, from its having formerly been cast into small balls, and stained of a plum colour, *sal prunelle*. At a strong red heat it is decomposed, with the evolution of oxygen and the formation of hyponitrite of potash (see *ante*, p. 268), which, when rubbed to powder and mixed with sulphuric acid, emits red fumes (composed of nitrous acid and binoxide of nitrogen). One hundred parts of water at 32° dissolve 13·32 parts of this salt, but at 77° they dissolve 38 parts. During the solution cold is generated. In pure alcohol nitre is insoluble.

Characteristics.—This salt is known to be a nitrate by the characters already detailed (see *ante*, p. 412) for this class of salts. That its base is potash is shewn by the tests before mentioned (see *ante*, p. 463) for this substance.

COMPOSITION.—Nitrate of potash has the following composition:—

	Atoms.	*Eq. Wt.*	*Per Cent.*	*Wollaston.*	*Longchamp.*	*Thomson.*
Potash	1	47	46·535	46·668	46·703	45·66
Nitric Acid	1	54	53·465	53·332	53·297	54·34
Nitrate of Potash	1	101	100·000	100·000	100·000	100·00

IMPURITIES.—Nitrate of potash is sometimes contaminated with alkaline or earthy chlorides or sulphates; the mode of recognising which has already been pointed out (see *ante*, p. 509).—Nitrate of potash, when pure, undergoes no change by exposure to the air; but if nitrate of soda be present, this absorbs moisture. The presence of nitrate of soda is detected by the yellow colour which it communicates to flame; whereas that produced by potash only is violet (see *ante*, pp. 463 and 496).

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[1] Levy, *Quarterly Journal of Science*, vol. xv. p. 284; also Miller, in *Philosophical Magazine* for July 1840.

PHYSIOLOGICAL EFFECTS. α. *On Vegetables.*—Nitrate of potash dissolved in 300 times its weight of water promotes vegetation: but a solution containing $\frac{1}{30}$ part of nitre is injurious to the growth of plants.[1] Some interesting details on the use of alkaline nitrates are given by Mr. Johnstone.[2] He says that they increase the production of woody matter of plants; but no well-ascertained facts have yet been obtained to determine the differential effects of the nitrates of potash and soda.

β. *On Animals generally.*—Orfila[3] found that when introduced into the stomach of dogs it acts as an irritant poison. If administered in doses of two or three drachms, it is capable, when not vomited up, of causing death. Its operation is that of a narcotico-acrid poison. When applied to the cellular tissue it produces, according to this experimentalist, local effects only, and does not become absorbed. But Devergie[4] states, on the authority of J. E. M. Smith, that half an ounce applied to the thigh killed a dog in thirty-six hours. Eight ounces dissolved in a pint of water, and swallowed, killed a horse in twenty-four hours with all the symptoms of violent intestinal irritation.[5] Veterinarians use nitre as a diuretic and refrigerant in doses of from two to four drachms.

γ. *On Man.*—In *very large doses* (such, for example, as one ounce or more) nitre has in several instances caused death;[6] but the effects of it are not uniform, since, in other cases, this quantity has not appeared to have any very remarkable or obvious effect. For example, Dr. Christison knew an instance in which one ounce was taken without occasioning any other unpleasant symptom than vomiting; and it was retained on the stomach for above a quarter of an hour. In a case reported by Mr. Gillard a man recovered in four days from the use of two ounces of nitre taken by mistake for Epsom salts. In those cases where violent effects followed the ingestion of it, the symptoms were two-fold: on the one hand, those indicating irritation of the alimentary canal (such as pain, vomiting, and sometimes purging); on the other hand, an affection of the nervous system (marked by giddiness, convulsions, failure of pulse, tendency to fainting, dilated pupil, insensibility, and palsy.) In a case related by Dr. Geoghegan, (quoted by Mr. Taylor) death occurred in two hours from an ounce and a half; in Orfila's case one ounce caused death in three hours; and in another case which occurred in Manchester, ten drachms caused diarrhœa and death in five hours. In other cases the death has been less speedy: in one instance it did not occur till sixty hours after the ingestion of an ounce and a half of the salt. It is probable that the operation of nitre is influenced by the quantity of aqueous liquid in which the salt is dissolved, and that the more we dilute, the less powerfully does it act as a poison. In no other way can we reconcile the discrepant statements in regard to the effects produced by an ounce of nitre.

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[1] Davy, *Agricultural Chemistry.*

[2] *Lectures on Agricultural Chemistry*, p. 591 *et seq.* 2d edit.

[3] *Toxicol. Générale.*

[4] *Médecine Légale.*

[5] Moinroud, *Pharmacologie Vétérinaire*, Paris, 1831.

[6] See Mr. A. S. Taylor's work *On Poisons.*

In *moderate doses*, nitre acts as a refrigerant, diuretic, and diaphoretic. Its refrigerant properties are best seen when the body is preternaturally hot, as in febrile disorders. Mr. Alexander,[1] in his trials with it, made on himself, experienced a sensation of chilliness after each dose, but he could not recognise by the thermometer any diminution of heat in the external parts of his body. He found, in most of his experiments, that it had a powerful influence over the vascular system, and surprisingly diminished, in a very short period of time, the number of pulsations. Thus, on several occasions, a drachm of this salt, within a few minutes, reduced the frequency of the pulse from 70 to 60 beats. Diuresis is another effect. As the nitre can be detected in the urine (see *ante*, p. 101), its operation as a diuretic depends, perhaps, on the local stimulus which is communicated to the renal vessels while the salt is passing through them. Like most of the neutral salts of the alkalies, the continued use of it promotes alvine evacuations. Full doses frequently produce pain in the stomach. As a diaphoretic, it is usually given in combination with emetic tartar.

Various effects on the blood have been ascribed to nitre: some of these have been already alluded to. One of them is a physical or endosmotic effect exercised by this salt, before its absorption, on the serum of the blood, through the coats of the vessels (see *ante*, pp. 91 and 92). After its absorption, it is probable that it may exert a similar endosmotic influence over the blood-corpuscles, and cause them to collapse or contract. Several chemical effects on the blood have likewise been ascribed to it. Its antiplastic or plastilytic effect has been already alluded to (see *ante*, pp. 109 and 179). Zimmermann[2] has suggested, that in thoracic inflammation nitre promotes absorption of the effused products by preventing the coagulation of the fibrine, and rendering the effused plasma more soluble, and thereby more readily absorbable. Another effect which this, in common with other saline substances, produces on the blood, and which I have before noticed (see *ante*, p. 179), is that of diminishing the adhesiveness of the blood-corpuscles for each other. A third chemical effect is the change which it occasions in the colour of the blood. If it be mixed with dark-coloured venous blood out of the body, it communicates to it a florid or arterial hue. Now as this salt, when taken into the stomach, becomes absorbed, it is not unreasonable to suppose that while mixed with the circulating blood it might have an analogous effect. Dr. Stevens[3] asserts, that in the last stage of fever, when the blood is black, it has this effect. Moreover, he tells us (p. 154), that in a case which occurred in America, where a person swallowed an ounce of nitre by mistake, in place of Glauber's salts, the blood when drawn from a vein was completely florid, and remained as fluid as if the nitre had been added to it out of the body.[4]

USES.—It follows, from what has been now stated in regard to the physiological effects of nitre, that this substance is indicated when we wish to diminish preternatural heat, and to reduce the force and frequency of the pulse, as in febrile disorders, inflammatory affections, (except, perhaps, those of the stomach, bowels, kidneys, and bladder), and hemorrhages[1] (especially hæmoptysis). In continued fever it is frequently given in combination with emetic tartar, and sometimes also with calomel.

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[1] *Essays*, p. 105, *et seq.* Edinb. 1768.

[2] *London Medical Gazette*, Jan. 22, 1847, p. 175.

[3] *Observations on the Blood*, p. 298, Lond. 1832.

[4] For some remarks on the effects of nitre on the blood, by Mr. Carlyon, see *Lond. Med. Gaz.* vol. viii. p. 626; and on nitre as a therapeutic agent, by Dr. Hancock, see *Lancet* for 1831-2, vol. ii. p. 766.

In acute rheumatism large doses of nitre have been administered, apparently, in many cases, with great success. They were first employed about the middle of the last century by Dr. Brocklesby,[2] who gave this salt to the extent of ten drachms or more, dissolved in three, four, or five quarts of thin gruel in twenty-four hours. Within three or four days the malady was much relieved or even cured under great sweating. Until the last ten or twelve years this method of treatment had for the most part fallen into disuse: it has, however, lately been revived, principally by some French physicians. According to Dr. Henry Bennet[3] the revival is due to Gendrin. But Martin Solon (whose observations have been reported by Aran),[4] Stœber, Forget,[5] and others, have borne evidence to the success of the practice. Bouchardat,[6] however, observes that this method of treatment had been repeatedly tried in the practice of the Hôtel-Dieu; but either from the physicians of that hospital not finding it more efficacious than simple expectation, or because they feared the action of a too energetic an agent, the trials of it were not long continued. Gendrin generally begins by four drachms in the twenty-four hours with an adult female, and six drachms, in the same period, with an adult male; and he rapidly increases the dose to eight, ten, or twelve drachms, seldom carrying it further. Aran states that the mean quantity employed in twenty-four hours is about eight drachms, and that the mean quantity administered during the disease has been about twelve ounces! The salt should be given dissolved in a large quantity of liquid. Aran says the eight drachms were given in about three wine-quarts of tisane. Bennet states that it should be given in a large quantity of weak lemonade or barley water, properly sweetened, in the proportion of about four drachms of nitre to a pint and a half of gruel. The obvious effects produced are usually copious sweating, sometimes diuresis, sometimes purging. Under its influence the force and frequency of the heart's action are diminished. Ill effects from its use are stated to be rare. In acute rheumatism it sometimes fails to give any relief: in chronic rheumatism it is useless.

It is not often used as a diuretic, because its activity in this respect is not very great; but it is adapted for those cases which are accompanied with arterial excitement.

Dr. Young has successfully employed nitrate of potash in the treatment of incontinence of urine in children. It acts, he says, as a stimulant to the bladder or its sphincter.

In sore-throat it is mixed with white sugar, and gradually swallowed. A mixture of nitre and powdered gum has long been a favourite remedy for diminishing the scalding of gonorrhœa.

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[1] Gibbons, *Medical Cases and Remarks*, Part II. *On Nitre in Hæmorrhagy*, 2d ed. Sudbury, 1811.

[2] *Œconomical and Medical Observations*, p. 116, Lond. 1764.

[3] *Lancet*, Feb. 10 and June 15, 1844.

[4] *Journal des Connaissances Medico-Chirurgicales*; also, *Annuaire de Thérapeutique*, 1842.

[5] *Ann. de Thérap.* 1844.

[6] *Ibid.* 1842.

Nitre is rarely employed as an external agent, except as a means of producing cold. Thus, five ounces of nitrate of potash, with five ounces of sal ammoniac, dissolved in sixteen ounces of water, reduces the temperature 40° F.; that is, from 50° to 10°, according to Mr. Walker. Hence, therefore, we sometimes employ this mixture, placed in a bladder, as an external application (see *ante*, p. 34.)

On the belief that fever, cholera, and other malignant diseases, were produced by a deranged state of the blood, and that this derangement depended on, or consisted in, a diminution or entire loss of the saline parts of the blood, Dr. Stevens employed nitre, chloride of sodium, and other alkaline salts, in the treatment of these diseases.[1] I have before (see *ante*, p. 181) had occasion to refer to this subject.

Nitre, in large doses, has been employed in the treatment of scurvy, and with considerable success, according to the statement of Mr. Cameron.[2] This accords with Dr. Garrod's views already explained (see *ante*, p. 464).

Administration.—It may be given in doses of from ten grains to half a drachm, in the form of powder, mixed with sugar, or in solution. If administered as a refrigerant, it should be dissolved in water and immediately swallowed, in order that the coldness of the solution may assist the action of the salt. If employed as a diuretic, we ought to give mild liquids plentifully, and keep the skin cool.

Antidote.—No chemical antidote for this salt is known. In case of poisoning, therefore, we should remove the poison from the stomach as speedily as possible, and administer tepid emollient drinks. Opiates, perhaps, may be advantageously administered. The inflammatory symptoms are to be combated by the usual antiphlogistic measures.

INHALATIO NITROSA; *Fumigatio Nitrosa.*—The fumes produced by the deflagration of nitrate of potash with paper have been inhaled with benefit in spasmodic asthma.[3] To obtain them, blotting paper is to be dipped in a saturated solution of nitre, and afterwards dried: by this means we obtain what is commonly called *touch paper*. The fumes evolved by its ignition are to be inhaled either by setting fire to the paper on a plate, or rolled up and placed in a candlestick, and letting the fumes escape into the room, the air of which soon becomes sensibly impregnated with them; or by smoking the paper in a tobacco pipe. In about a quarter of an hour the patient experiences their beneficial effects.

51. POTASSÆ ACETAS.—ACETATE OF POTASH.

Formula $KO,C^4H^3O^3$; or $KO,\bar{A}$. *Equivalent Weight* 98.

History.—It appears to have been first clearly described by Raymond Lully in the thirteenth century, and has been known by several appellations; such as *terra foliata tartari*, *diuretic salt* (*sal diureticus*), *regenerated tartar* (*tartar regeneratus*), *arcanum tartari*, and *kali acetatum*.

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[1] Stevens, *op. supra cit.* pp. 296, 298, &c.

[2] *Medico-Chirur. Review*, March 1830, p. 483.

[3] *London Medical Gazette*, Sept. 4, 1846, p. 431.

NATURAL HISTORY.—Geiger[1] says this salt is found in some mineral springs. It exists in the juices of many plants. The sap of the elm, and of most trees, Winter's bark, linseed, senna leaves, the rhizome of ginger, &c. are said to contain it.

PREPARATION.—All the British Colleges give directions for the preparation of this salt.

The *London College* orders of Carbonate of Potash, lbj.; Acetic Acid, f℥xxvj.; Distilled Water, f℥xij. Add the carbonate of potash to the acid, first mixed with water, to saturation, then strain. Evaporate the liquor in a sand-bath, the heat being cautiously applied, until the salt is dried.

The *Edinburgh College* orders of Pyroligneous Acid, Oiss.; Carbonate of Potash (dry), ℥vij., or a sufficiency. Add the carbonate gradually to the acid till complete neutralization is accomplished. Evaporate the solution over the vapour-bath till it is so concentrated as to form a concrete mass when cold. Allow it to cool and crystallize in a solid cake; which must be broken up, and immediately put into well-closed bottles.

The *Dublin College* gives the following directions for its preparation:—Take of Carbonate of Potash from Crystals of Tartar any required quantity. Pour on it, by repeated additions, Distilled Vinegar of a *medium* heat, and in quantity about five times the weight of the salt. When the effervescence shall have ceased, and the liquor have given off vapours during some time, let the additions of distilled vinegar be repeated at intervals, until effervescence shall have completely ceased. By continued evaporation the salt will become dry, and by a moderate increase of the heat it is to be cautiously liquefied. When the salt has cooled, let it be dissolved in water: filter the liquor, and boil it down until, when removed from the fire, on cooling, it forms a mass of crystals.

In this process the acid unites with the potash of the carbonate, and disengages carbonic acid. $KO,CO^2+\bar{A}=KO,\bar{A}+CO^2$.

To obtain a perfectly white mass, pure acetic acid should be used; and to prevent the salt from becoming yellow or brown during the evaporation of the solution, a slight excess of acid should be present.

PROPERTIES.—It is usually met with as a colourless, white solid, with a foliated texture (which is given to it by fusion and cooling), odourless, but having a pungent saline taste and a soapy feel. It is exceedingly deliquescent, and, therefore, ought to be preserved in a well-stoppered bottle. It is very soluble both in water and alcohol; indeed, in water, it is one of the most soluble salts we are acquainted with. At 60°, 100 parts of the salt will dissolve in 102 parts of water.

Characteristics.—As a potash salt, it is known by the tests for this base, before described (see *ante*, p. 463). As an acetate, it is recognised by the tests for acetic acid hereafter to be stated. Its deliquescence is also a characteristic.

COMPOSITION.—Its composition is as follows:—

	Atoms.	*Eq. Wt.*	*Per Cent.*	*Wenzel.*	*Richter.*
Potash	1	47	47·96	50·15	51·4
Acetic Acid (dry)	1	51	52·04	49·85	48·6
Acetate of Potash	1	98	100·00	100·00	100·0

IMPURITY.—It should be white and perfectly neutral. Frequently, however, it reacts on test-paper as an alkali, owing to a slight excess of potash. The presence of chlorides may be detected by nitrate of silver; of sulphates, by chloride of barium; of metals, by hydrosulphuric acid or ferrocyanide of potassium.

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[1] *Handbuch der Pharmacie.*

Physiological Effects.—Two or three drachms cause purging, which is sometimes accompanied with griping. In smaller doses, more especially if largely diluted (see *ante*, p. 252), it acts as a diuretic and mild diaphoretic. In its passage to the kidneys, it becomes decomposed, and is converted into the carbonate of potash (see *ante*, p. 180), which may be detected in the urine (see *ante*, p. 102). Probably the pulmonary excretions of those who employ it also become impregnated with this salt, since it has been said that in persons with delicate lungs it acts as an irritant to these organs.

Uses.—In this country it is rarely employed, except as a diuretic in dropsical complaints. It is a valuable adjunct to other renal excitants. On the continent it is administered in various diseases as an alterative or resolvent. Thus in scirrhus of the pylorus, chlorosis, and visceral and glandular enlargements. It may be employed in the lithic acid diathesis to render the urine alkaline. It is of course improper when phosphatic deposits are observed in the urine.

Administration.—It is given as a diuretic in doses of from a scruple to a drachm and a half, dissolved in some mild diluent. In larger doses, as two or three drachms, it acts as a purgative.

52. POTASSÆ TARTRATES.—TARTRATES OF POTASH.

Two compounds of potash and tartaric acid are known: they are

1. The neutral or bibasic tartrate of potash	$2KO,\bar{T}$
2. The acid or monobasic tartrate (bitartrate) of potash	$KO,\bar{T}$

Both of these salts are employed in medicine.

1. Potassæ Tartras.—Neutral or Bibasic Tartrate of Potash.

Formula $2KO,C^8H^4O^{10}$; or $2KO,\bar{T}$. *Equivalent Weight* 225.

History.—This salt was known to Lemery. It has been termed *soluble tartar* (*tartarum solubile*), *tartarized tartar* (*tartarus tartarizatus*), *tartarized kali* (*kali tartarizatum*), *vegetable salt* (*sal vegetabile*), &c. It is the *tartrate of potash* (*potassæ tartras*) of the Pharmacopœias.

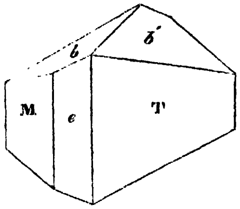
Preparation.—All the British Colleges give directions for its preparation.

The *London College* orders of Bitartrate of Potash, powdered, lbiij.; Carbonate of Potash, ℥xvj., or as much as may be sufficient; Boiling Water, Ovj. Dissolve the carbonate of potash in the boiling water, then add the bitartrate of potash, and boil. Strain the liquor, and afterwards boil it down until a pellicle floats, and set it aside that crystals may be formed. The liquor being poured off, dry these, and again evaporate the liquor that crystals may be produced.

The processes of the *Edinburgh* and *Dublin Colleges* are essentially the same.

In this process the excess of acid in the bitartrate is saturated by the potash of the carbonate: the carbonic acid escapes. Or if we assume tartaric acid to be a bibasic acid, cream of tartar is to be regarded as a monobasic tartrate of potash, and on the addition of another atom of acid, it becomes a bibasic tartrate.

FIG. 85.



Crystal of Tartrate of Potash.

PROPERTIES.—It is usually met with in the shops in a granular state; but it ought to be crystallized. Its crystals are right rhombic prisms. To the taste this salt is saline, and somewhat bitter. It deliquesces when exposed to the air, and is soluble in its own weight of water at 50°: the solution decomposes by keeping.

Characteristics.—Its characteristics are those of a potash salt (see *ante*, p. 463) and of a tartrate (see *Acidum Tartaricum*). When heated to redness it is decomposed, leaving as a residue charcoal and carbonate of potash. When heated, the salt evolves the odour of caramel. If an excess of a strong acid (as the sulphuric) be added to a solution of this salt, we obtain crystals of the bitartrate. Hence acids, and most acidulous salts, are incompatible with it, as also are tamarinds. The tartrate is readily distinguished from the bitartrate by its deliquescent property, its greater solubility, and its want of acidity.

COMPOSITION.—The following is the composition of this salt:—

	Atoms.	*Eq. Wt.*	*Per Cent.*	*Berzelius.*
Potash	2	94	41·593	41·31
Tartaric Acid	1	132	58·407	58·69
Neutral Tartrate of Potash	1	226	100·000	100·00

The large crystals contain, according to Dr. Thomson,[1] four equivalents of water, $2KO,\bar{T},4HO$. The same authority states that he has had crystals of this salt in needles which seemed to contain no water of crystallization.

IMPURITY.—It may contain excess of acid or of base, either of which is easily recognised;—the one by litmus, the other by turmeric. The sulphates may be detected by chloride of barium throwing down a white precipitate insoluble in nitric acid.

PHYSIOLOGICAL EFFECTS.—This salt is a gentle purgative and diuretic. Like the other vegetable salts of the alkalies, it is decomposed in the system, and converted into the carbonate (see *ante*, p. 180), in which state it is found in the urine, to which it communicates alkaline properties (see *ante*, p. 102).

It is said to have the power of preventing the griping of other more active cathartics, as senna and scammony; but, from my own personal observations, I doubt the correctness of this statement.

USES.—It is employed as a mild purgative in dyspepsia, at the commencement of diarrhœa, in some liver complaints, &c. Sometimes it is used as an adjunct to other more active purgatives, as the infusion of senna. It may be used in lithiasis to render the urine alkaline, in which case it must be used in the form of a dilute solution (see *ante*, p. 92). Liebig[2] has proposed to employ it as an agent for destroying the acidity of Rhine wines.

ADMINISTRATION.—It may be given in doses of from two or three drachms to half an ounce, or even an ounce.

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[1] *First Principles of Chemistry*, vol. ii. p. 204.

[2] *Pharmaceutical Journal*, vol. viii. pp. 63 and 90.

2. Potassæ Tartras Acida.—The Acid or Monobasic Tartrate of Potash.

Formula $KO,C^8H^4O^{10}, HO$; or $KO,\bar{T},HO$. *Equivalent Weight* 188.

HISTORY.—In its impure form, as a deposit from wine, it must have been known at a very early period. "It is called *tartar*," says Paracelsus, "because it produces oil, water, tincture, and salt, which burn the patient as *hell* does." Scheele, in 1769, first explained its nature. It is known by the various names of *bitartrate* (*potassæ bitartras*, Ph. L. E. D.), *supertartrate*, or *acidulous tartrate of potash*, or *cream of tartar* (*cremor tartari*).

NATURAL HISTORY.—It is a constituent of many vegetable juices, especially of grape juice, from which the whole of the commercial bitartrate is procured. It is more abundant in unripe than in ripe grapes. It is also found in many other vegetables, as tamarinds.

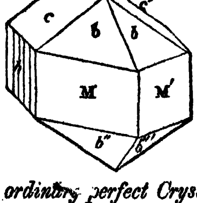
PRODUCTION.—All the acid tartrate of commerce is obtained during the vinous fermentation. It exists in solution in grape juice; but being very slightly soluble in a mixture of alcohol and water, it deposits during fermentation (that is, when alcohol is produced), and forms a crust on the sides of the cask. In this state it is known in commerce under the name of *crude tartar* (*tartarus crudus*), or *argol*, and which is termed *white* or *red* (*tartarus albus* vel *tartarus ruber*), according as it is obtained from white or red wine.

Argol, or *crude tartar*, occurs in crystalline cakes of a reddish colour, and is composed of the bitartrate of potash, tartrate of lime (and sometimes biracemate of potash), colouring and extractive matter, &c.

At Montpellier, tartar is procured thus:—Argol is boiled in water, and the solution allowed to cool, by which a deposit of crystals is obtained; these are washed with cold water, and dissolved in boiling water containing charcoal and alumina (clay), the latter substances being employed to remove the colouring matter with which they precipitate. The clear liquor is allowed to cool slowly, by which crystals are formed. These constitute the *tartarus depuratus* or *crystalli tartari* of the older chemists. If a hot saturated solution of tartar be cooled, the surface of the liquid becomes coated by a layer of very fine crystals of bitartrate: hence this crust was called *cream of tartar* (*cremor tartari*).

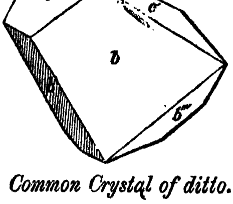
PROPERTIES.—As met with in commerce, this salt forms a white crystalline mass, without odour, but having an acidulous and gritty taste. According to Mr. Brooke[1] its crystals are right rhombic prisms (figs. 86 and 87). Liebig,[2] however, says they are oblique rhombic prisms. It is unaltered by exposure to the air; but when heated, it decomposes, swells up, evolves various volatile products, gives out an odour of caramel, and is converted

FIG. 86.



An ordinary perfect Crystal of Bitartrate of Potash.

FIG. 87.



Common Crystal of ditto.

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[1] *Ann. of Phil.* N. S. vol. vii. p. 161.

[2] Turner's *Chemistry*, 7th edit.

into *black flux* (*fluor niger*),—a compound of charcoal and carbonate of potash. If made with raw tartar containing nitrogen, the black flux will be contaminated with bicyanide of potassium (see *ante*, p. 474). If the acid tartrate be deflagrated with nitrate of potash, the residue is *white flux* (*fluor albus*), or carbonate of potash (see *ante*, p. 474). Bitartrate of potash is very slightly soluble in water, and is insoluble in alcohol.

Characteristics.—One character of this salt is derived from the phenomena attending its conversion into black flux, as above mentioned. If black flux be digested in water, we obtain a solution of carbonate of potash, the characteristics of which have been before stated (see *ante*, p. 475). Another character of the bitartrate is its slight solubility in water, and its solution reddening litmus. The addition of caustic potash increases its solubility, whereas alcohol diminishes it. Acetate of lead added to a solution of the bitartrate forms a copious white precipitate: lime water has the same effect. Mixed with alkaline carbonates, it produces effervescence.

COMPOSITION.—Crystallized acid tartrate (bitartrate) of potash has the following composition:—

	Atoms.	*Eq. Wt.*	*Per Cent.*	*Berzelius.*
Potash	1	47	25·00	24·80
Tartaric Acid	1	132	70·21	70·45
Water	1	9	4·79	4·75
Crystallized Acid Tartrate of Potash	1	188	100·00	100·00

IMPURITY.—Acid tartrate of potash when pure is quite white. As found in commerce it usually contains from 2 to 5 per cent. of tartrate of lime; and hence a little carbonate of lime may be detected in black flux. This is of no material consequence in a medicinal point of view. To detect the tartrate of lime, digest the suspected acid tartrate of potash, with a solution of caustic ammonia, and test the filtered solution with oxalate of ammonia. If the powdered acid tartrate be adulterated with either alum or bisulphate of potash, the fraud may be detected by chloride of barium, which causes a white precipitate (*sulphate of baryta*) insoluble in nitric acid. Sulphuretted hydrogen and solution of ferrocyanide of potassium should produce no change in a solution of this salt.

To detect racemic acid, proceed thus:—Saturate the suspected acid tartrate of potash, with pure carbonate of potash, then add lime water, and afterwards sal ammoniac. If the sal ammoniac does not completely dissolve the precipitate caused by the lime water, racemate of lime is present.

It is sparingly dissolved by water. It renders the colour of litmus red. At a red heat it is converted into carbonate of potash.—*Ph. Lond.*

"Entirely soluble in 40 parts of boiling water: forty grains in solution are neutralized with 30 grains of crystallized carbonate of soda; and when then precipitated by 70 grains of nitrate of lead, the liquid remains precipitable by more of the test."—*Ph. Ed.*

PHYSIOLOGICAL EFFECTS.—When taken in *small doses*, diluted with water, it acts as a refrigerant and diuretic; in *larger doses* (as two or three drachms) it purges, and frequently creates flatulence and griping. By continued use it disorders the digestive functions, and causes emaciation, most probably from defective nutrition. In *excessive doses* it produces inflammation of the stomach and intestines. A fatal case has been recorded by Mr.

Tyson.[1] A man, to relieve the effects of drunkenness, swallowed four or five table-spoonfuls of cream of tartar. It caused violent vomiting and purging, and other symptoms of gastro-enteritis, and pain in the loins. The thighs and legs appeared paralyzed. He died on the third day. On a post-mortem examination, the stomach and intestines were found inflamed. The changes which the bitartrate undergoes during its passage through the system, and its effects on the urine, have already been pointed out (see *ante*, p. 180).

USES.—Acid or bitartrate of potash is frequently employed to form a refrigerant drink in febrile and inflammatory diseases. It allays thirst, diminishes preternatural heat, and reduces vascular action. As a *diuretic* in dropsical complaints, it is used either in the same way, or taken in the form of an electuary. As a *purgative* it is not usually exhibited alone, but, in general, with jalap, sulphur, senna, or some other purgative. Thus, in dropsical complaints, a very valuable hydragogue cathartic is a mixture of jalap and bitartrate of potash. In skin diseases and affections of the rectum (as piles, stricture, and prolapsus), a very useful purgative is an electuary composed of sulphur, bitartrate of potash, and confection of senna. An effervescing aperient may be prepared by mixing three drachms of the bitartrate with two and a half drachms of carbonate of soda: the resulting salt is the potash-tartrate of soda. As a *tooth-powder*, bitartrate of potash is sometimes used on account of its gritty qualities: a very good dentifrice consists of equal parts of bitartrate, powdered rhatany root, and myrrh (see *ante*, p. 155).

ADMINISTRATION.—As a hydragogue cathartic, the dose is from four to eight drachms; as an aperient, one or two drachms; as a diuretic, in repeated doses of a scruple to a drachm (see *Pulvis Jalapæ Compositus*).

1. **POTUS IMPERIALIS**; *Tisana Imperialis*; *Imperial.*—It is formed by dissolving one drachm or a drachm and a half of cream of tartar in a pint of boiling water, and flavouring with lemon-peel and sugar. When cold, the solution may be taken, *ad libitum*, as a refrigerant drink in febrile complaints, and as a diuretic.

2. **SERUM LACTIS TARTARIZATUM**; *Cream of Tartar Whey.*—This is prepared by adding about two drachms of the bitartrate to a pint of milk. It may be diluted with water, and taken in febrile and dropsical complaints.

53. Potassæ Boro-tartras.—Boro-tartrate of Potash.

The addition of either boracic acid or borax to cream of tartar greatly increases the solubility of the latter; and the compound produced has been termed *soluble cream of tartar (cremor tartari solubilis).* It was discovered by Le Fèvre in 1732.

In the French Codex, the *tartras borico-potassicus* is prepared by dissolving 40 parts of bitartrate of potash and 10 parts of crystallized boracic acid in 240 parts of water, and evaporating the solution either to dryness or to a syrupy consistence, and then spreading it on plates to dry. The compound thus obtained is white, has a sour taste, is incapable of crystallizing, and is soluble in water in all proportions. According to Soubeiran, soluble cream of tartar, when chemically pure and saturated with boracic acid, consists of $KO,2\overline{T}+BO^3$ or $KO,\overline{T}+BO^3\overline{T}$.

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[1] *London Medical Gazette*, vol. xxi. p. 177.

In the Prussian Pharmacopœia, *tartarus boraxatus* is prepared by dissolving one part of borax in ten parts of boiling water, and then adding three parts of depurated tartar deprived of tartrate of lime. The solution is to be evaporated, by a gentle heat, in a vapour bath, until it becomes a tenacious mass: it is then to be placed on paper, dried by a gentle heat, and rubbed to powder. It is a white deliquescent powder, having an acid taste, and being soluble in its own weight of water. According to Duflos, it consists of $KO,NaO,2\overline{T}+2(KO,BO^3,2\overline{T})+3HO$.

Boro-tartrate of potash partakes of the medicinal properties of cream of tartar and borax. Its great solubility gives it an advantage over cream of tartar. In doses of from half to an ounce it acts as a cooling purgative. In smaller doses it is diuretic, and is said to be emmenagogue. It has been employed in dropsical affections, amenorrhœa, hepatic congestion, and various other maladies. As a resolvent, it is given in doses of a scruple. It has been recommended by Mr. Ure[1] as a solvent for lithic acid calculi.

54. Potassæ Citras.—Citrate of Potash.

Formula $3KO,C^{12}H^5O^{11}$; or $3KO,\overline{Ci}$. *Equivalent Weight* 306.

Neutral Citrate of Potash; Sal Absinthii citratum; Tribasic Citrate of Potash.—Prepared by saturating a solution of crystallized citric acid with bicarbonate of potash and evaporating to dryness.—If lemon-juice be substituted for the solution of citric acid, the resulting compound will contain, besides some mucilaginous and extractive matter, a portion of malate of potash (*kali malico-citratum*).—If commercial carbonate of potash be substituted for the bicarbonate, some hydrate of silica separates when the carbonate is saturated with citric acid.

Neutral citrate of potash is a deliquescent solid, and, therefore, requires to be kept in well-stoppered vessels. It may be obtained in stellated groups of acicular deliquescent crystals, having an alkaline flavour, and which, according to Heldt, contain 2HO. It is insoluble in alcohol.

Citrate of potash agrees very much with the other vegetable salts of the alkalies in its medicinal effects. It acts mildly on the skin, bowels, and kidneys, whose secretions it promotes. It is an excellent refrigerant, soothing or sedative diaphoretic in fevers with a hot and dry skin, and is less apt to act on the bowels than the tartrate or acetate of potash. When there is a tendency to diarrhœa, the citrate may be combined with an opiate. It is peculiarly valuable when the stomach is irritable. Like the other vegetable salts of the alkalies, it communicates an alkaline quality to the urine (see *ante*, pp. 102 and 180). The dose of the solid citrate is ℈j. to ʒss. dissolved in a fluidounce of water, sweetened, if desired, with syrup, and taken every two or three hours as occasion may require.

1. LIQUOR POTASSÆ CITRATIS, Ph. United States; *Solution of Citrate of Potash (Neutral Mixture).*—Take of Fresh Lemon-juice, half a pint; Carbonate of Potassa, a sufficient quantity. Add the Carbonate of Potassa gradually to the Lemon-juice till it is perfectly saturated; then filter. Or, take of Citric Acid, half an ounce; Oil of Lemons, two minims; Water, half a pint; Carbonate of Potassa, a sufficient quantity. Rub the Citric Acid with the Oil of Lemons, and afterwards with the Water, till it is dissolved; then add the Carbonate of Potassa gradually till the Acid is perfectly saturated; lastly, filter.

The dose of this officinal solution is a tablespoonful, or half a fluidounce, diluted with about an equal measure of water.

2. LIQUOR POTASSÆ CITRATIS EFFERVESCENS; *Effervescing Solution of Citrate of Potash.*—This constitutes the common *effervescing draught (haustus effervescens)*, or *Riverius's potion (potio Riverii)*. It is an extemporaneous solution of citrate of potash given in a state of effervescence; and is prepared with bicarbonate of potash and either citric acid or lemon-juice. The latter yields a somewhat more agreeable draught, but is not of uniform strength. The following is a formula for its preparation:—

℞ Potassæ Bicarbonatis, gr. xxv.; Syrupi Aurantii, Tinct. Cardamomi Co. āā. ʒj.; Aquæ distillatæ, ʒvj. M. fiat haustus, cum succi limonum recentis fʒss. vel quantum sufficit, in actu effervescentiæ, sumendus.

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[1] *Pharmaceutical Journal*, vol. i. p. 191.

Instead of lemon-juice, 17 grains of crystallized citric acid, dissolved in half an ounce of water, may be substituted. The solution may be flavoured with sugar and oil of lemons.

This draught possesses the properties of the citrate of potash above mentioned in addition to those derived from the presence of the carbonic acid. It is a most valuable remedy for allaying irritability of stomach, and has the additional advantage of being very grateful, for the carbonic acid covers the taste of the citrate. Where the vomiting is very rebellious, two or three drops of the *acidum hydrocyanicum dil.* (Ph. Lond.) may be added to the draught. In fever where there is a tendency to diarrhœa, it will be sometimes advisable to reduce the proportions of bicarbonate and citric acid used in preparing the draught, and to add a small quantity of syrup of poppies.

The preparation called *lemon and kali* has been already noticed (see *ante*, p. 480).

55. Potassæ Oxalates.—Oxalates of Potash.

Three compounds of potash and oxalic acid are known.

1. **Potassæ Monoxalas**; *Oxalate of Potash; Neutral Oxalate of Potash.*—Obtained by saturating a solution of oxalic acid by carbonate of potash. In the crystalline state, its formula is KO,C^2O^3,HO. It is not employed in medicine.

2. **Potassæ Binoxalas**; *Binoxalate of Potash.*—This salt is found in the juice of *Oxalis Acetosella* and *corniculata*, of *Rumex Acetosella* and *Acetosa*, of *Rheum palmatum*, *Spinacia oleracea*, *Atropa Belladonna*, *Phytolacca decandra*, and *Geranium acetosum*. It is obtained by saturating a solution of one portion of oxalic acid with carbonate of potash, then adding a second portion of the acid, and crystallizing. In some parts of Germany and Switzerland, it is procured on the large scale from wood-sorrel (*Oxalis Acetosella*) by evaporating the expressed juice, redissolving, and crystallizing. Five hundred parts of the plant yield four parts of the crystallized salt, which is termed the *salt of wood-sorrel*, or *sal acetosellæ*. It is not, however, the salt sold under these names in English commerce. It crystallizes in oblique rhombic prisms, which consist of $KO,2C^2O^3,3HO$; or, according to Graham, of KO,C^2O^3+HO,C^2O^3+2HO. If, of two equal quantities of this salt, one is exposed to a red heat to destroy the whole of its acid, the residual alkaline carbonate is just sufficient to neutralize the redundant acid of the other portion (Wollaston).

The oxalic acid contained in the binoxalate appears to pass through the system unchanged (see *ante*, pp. 102 and 178), and re-appears in the urine in the form of oxalate of lime. Hence, when crystals of the latter salt are desired for microscopic examination, they may be obtained by the employment of rhubarb tart or sorrel sauce at table. Those persons, however, who labour under the oxalic diathesis should carefully avoid the use of all such articles of food.

3. **Potassæ Quadroxalas**; *Quadroxalate of Potash.*—This salt is made by neutralizing a solution of one part of oxalic acid with carbonate of potash, and then adding three parts more of acid. It is sold in commerce under the name of *sal acetosellæ*, or *salt of sorrel;* and, from a mistaken notion that it is identical with the real salt of wood-sorrel, it is frequently termed *binoxalate of potash.* The *sel d'oseille* of French commerce is stated by Berard to be this salt; but Soubeiran says it is sometimes the binoxalate—sometimes the quadroxalate.

Quadroxalate of potash crystallizes in colourless transparent prisms of the doubly-oblique prismatic system; and which consist of $KO,4C^2O^3,7HO$, or, according to Graham, of $KO,C^2O^3+HO,C^2O^3+2(HO,C^2O^3+2HO)$. If three parts of the salt be converted into carbonate by heat, and added to a solution of one part, the neutral oxalate of potash is formed (Wollaston).

The commercial quadroxalate (salt of sorrel) is not pure; for I find that it yields, by ignition in a covered crucible, carbonate of potash, contaminated with carbonaceous matter; whereas the pure quadroxalate yields the carbonate only.

It is employed for removing ink stains and iron moulds from linen, and for decolorizing straw used for bonnet-making. This salt was formerly used in medicine as a refrigerant. In France, *tablettes ou pastilles la soif* are prepared with it. It possesses poisonous properties similar to, but less energetic than, oxalic acid. A case of poisoning by about an ounce of this salt has been published by my friend and former pupil, Mr. John Jackson.[1] The accident was not known for an hour and a half after it occurred. The symptoms were those of great depression of the heart's action, but without either tetanus or coma. The eyes were sore, the vision dim, the conjunctiva a good deal injured, and the pupils dilated. The patient ultimately recovered. Half an ounce of salt of sorrel, taken by a lady in mistake for cream of tartar, caused death in eight minutes.[2] The treatment of poisoning by this salt is the same as for oxalic acid (see *Acidum Oxalicum*).

Under the name of *salt of lemons (sal limonum)* is usually sold a mixture of two parts quadroxalate of potash (salt of sorrel) and one part cream of tartar. Sometimes, however, the quadroxalate alone is sold under this name.

ORDER XII. COMPOUNDS OF SODIUM.

Sodium or *natrium* (Na=23), the metallic basis of the alkali soda, has not hitherto been employed in medicine. It will not, therefore, require further notice.

56. Soda.—Soda.

Formula NaO. *Equivalent Weight* 31.

Fossil or Mineral Alkali; Caustic Soda; Oxide of Natrium.—First accurately distinguished from potash by Du Hamel in 1736. In combination it is found in the mineral kingdom, in plants (especially those which grow in, or on the borders of, the sea), and in many animal fluids. In the anhydrous state it is obtained by the oxidation of sodium. In its general properties it agrees very much with potash (see *ante*, p. 463), than which it is less caustic. Its solution produces no precipitate with the hydrosulphurets, ferrocyanides, phosphates, or carbonates. From a solution of potash it is distinguished by causing no precipitate with perchloric or tartaric acid (unless the solution be very concentrated), or with bichloride of platinum, and by the yellow tinge which it communicates to the flame of alcohol. The only substance capable of producing a precipitate in moderately dilute solutions of soda is antimoniate of potash, which causes a crystalline precipitate of antimoniate of soda. This test, however, is not applicable if other bases than those now mentioned be present. Sometimes the crystalline form of soda salts (as of the sulphate and nitrate) is resorted to as a means of distinguishing them from the potash salts.

Soda agrees with potash in most of its medicinal properties and uses (see p. 465). But, both in the caustic and carbonate state, it is less energetic in its chemical action on the tissues; and, according to Dr. Garrod (see *ante*, p. 464), it differs materially from potash in its relation to scurvy.

1. LIQUOR SODÆ; *Solution of Caustic Soda; Soap-boiler's Lye* (*lixivium saponarium*).—Obtained from carbonate of soda in the same way that liquor potassæ is procured from carbonate of potash (see *ante*, p. 468). It is not officinal; but is employed in the manufacture of hard soap.

2. SODÆ HYDRAS; *Hydrate of Soda.* NaO,HO.—Obtained from liquor sodæ as hydrate of potash is procured from liquor potassæ (see *ante*, p. 470). It is a constituent of soda-ash. It is not officinal.

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[1] *London Medical Gazette*, Dec. 18, 1840. In the same journal for March 5th, 1841, is a case of poisoning by about two scruples of oxalic acid swallowed in combination with carbonate of soda (*superoxalate of soda?*).

[2] *Ann. d'Hyg.* Avril, 1842, quoted by Mr. A. S. Taylor.

57. SODÆ CARBONATES.—CARBONATES OF SODA.

Soda and carbonic acid are said to combine in three proportions, and to form three distinct compounds, viz.:—

1. Monocarbonate, or neutral carbonate of soda........................	KO, CO^2
2. Sesquicarbonate of soda..	$2KO,3CO^2$
3. Bicarbonate of soda	$KO,2CO^2$

The sesquicarbonate is, perhaps, a compound of the other two carbonates.

1. Sodæ Monocarbonas.—Monocarbonate or Neutral Carbonate of Soda.

Formula NaO,CO^2. *Equivalent Weight* 53.

HISTORY.—Both this salt and the sesquicarbonate of soda were probably known to the ancients under the term of *νίτρον*, or *nitrum* (see p. 506). The *salt alkali*, or *sagimen vitri* of Geber,[1] was a carbonate of soda: the word *sagimen* is a corruption of the Hindee term *sajjiloon*.[2] In modern times this salt has had various appellations, such as *mild mineral* or *fossil alkali*, *aërated mineral alkali*, *subcarbonate of soda*, *natrum carbonicum*, and now usually *carbonate of soda* (*sodæ carbonas*, Ph. L.)

NATURAL HISTORY.—This salt is peculiar to the inorganised kingdom.

It is found in crystals, or in the form of an efflorescence, in several parts of the world; as in Egypt, Hungary, Bohemia, &c. The following are the results of various analyses of it:—

COMPOSITION OF NATRON.

	Egyptian.		*Hungarian.*			*Vesuvian.*	*Barbary.*	*Bohemian.*
			Border of Lac Blanc.	Commercial of Debrezin.			In small layers in common salt	
	(Klaproth.)[3]	(Beudant.)[4]	(Beudant.)	(Beudant.)	(Lampadius.)[5]	(Beudant.)	(Beudant.)	(Reuss.)[6]
Soda	32·6	43·8	50·2	43·2	14·2	46·7	43·6	89·18
Carbonic Acid		30·9	35·1	30·4		32·3	35·5	
Sulp^te Soda (dry)	20·8	7·3	*traces*	10·4	9·2	*traces*	..	..
Common Salt	15·0	3·1	..	2·2	22·4	2·7	..	..
Earthy matters	..	1·4	..	..	9·2	5·3	4·2	CaO,CO^2 7·44 MgO,CO^2 1·35
Water........	31·6	13·5	14·7	13·8	45·0	14·0	16·7	Extract^ve 2·03
	100.0	100·0	100·0	100·0	100·0	100·0	100·0	100·00

From these analyses it appears that the native monocarbonate of soda contains only one atom of water of crystallization. NaO,CO^2,HO.

It frequently occurs as an efflorescence on walls, sometimes in combination with sulphate of soda, and is probably derived from the soda salts contained in the limestone used for making mortar, or from the soda contained in the coals employed in burning the lime, or from the bricks or stones used as the building material. Carbonate of soda is a constituent of some mineral waters, which are, in consequence, termed *alkaline*, or, when they also contain a large excess of carbonic acid, *acidulo-alkaline* (see *ante*, p. 303).

PRODUCTION.—The commercial sources of carbonate of soda are three—viz. ative soda, the ashes of marine plants, and common salt or sulphate of soda.

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[1] *Invent. of Verity*, ch. iv.; and *Search of Perfection*, ch. iii.

It is [illegible] [2] Dr. Royle, *Essay on Hindoo Medicine*, p. 41.

straw used for *eiträge*, Bd. iii. p. 80, 1802.

In France, *table* *aité élémentaire de Minéralogie*, 2me éd. tom. ii. p. 310, 1832.

oted by Jameson, *Syst. of Mineralogy*, 2d edit. vol. ii. p. 312, 1816.

ed by Jameson, *ibid*.

1. *Native carbonate of soda.*—Egyptian natron is employed in the arts as carbonate of soda; but it appears to be sometimes mixed or combined with sesquicarbonate or bicarbonate (see *Sodæ Sesquicarbonas*).

The Hungarian native carbonate of soda, called *széksó*, exudes as an efflorescent crust upon the surface of the ground. It occurs near Mariatheresiopel, in the department of Bichar, and also in Lesser Cumania, near Szegedin, where there are five manufactories engaged in its production. The soda-earth is lixiviated, the solution evaporated to dryness, and the saline residue heated to redness to destroy the extractive matters. The carbonate of soda which is obtained is contaminated with sulphate of soda, chloride of sodium, and earthy impurities.[1]

2. *Ashes of marine plants.*—These are of two kinds—one, called *barilla*, obtained from phenogamous plants growing near the sea; the other, termed *kelp*, procured from cryptogamic plants growing in the sea.

a. **Preparation of Barilla.**—The substance called *barilla* (*sodæ carbonas venale; barilla*, D.) is an ash usually obtained by the combustion of plants belonging to the order Chenopodiaceæ; as species of Salsola, Salicornia, and Chenopodium. These are cultivated on the coasts, and when ripe are cut, dried, and burned in heaps: the resulting ash is barilla. It is a hard greyish or bluish mass, not deliquescent, having an alkaline acrid taste, and a peculiar odour. It consists of *carbonate* and *sulphate of soda*, *sulphuret* and *chloride of sodium*, *carbonate of lime*, *alumina*, *silica*, *oxide of iron*, and *carbonaceous matter* which has escaped combustion. The carbonate of soda is produced by the decomposition of the organic salts of soda contained in the plants before combustion. Several varieties of barilla are known in the market: they are distinguished by the names of the places from whence they are imported—namely, the Grand Canary and Teneriffe Islands, Alicant, Sicily, Carthagena, and the East Indies.

Canary barilla is procured from Salsola kali.[2]

Alicant barilla (*soda hispanica; soda alicantina*) is obtained from Salsola sativa, Chenopodium setigerum, and other species.[3] It yields from 25 to 40 per cent. of carbonate of soda.

Sicily barilla is procured principally from Salsola sativa: it furnishes, according to Fée,[4] 55 per cent. of carbonate of soda.

Of the *French barillas* two only deserve notice—namely, that of Narbonne, called *salicor*, and obtained from Salicornia herbacea, and which yields 14 or 15 per cent. of carbonate; and that of Aiguemortes, called *blanquette*, obtained from species of Salicornia, Salsola, and Atriplex, and which contains from 3 to 8 per cent. only of alkaline carbonate.

The importation of barilla has very much fallen off of late years, in consequence of the extraction of carbonate of soda from sulphate of soda. In 1827, the quantity imported was 326,239 cwts.;[5] whereas, in 1840, it was only 284 tons.[6]

β. **Preparation of Kelp.**—Kelp (called by the French *varec* or *Normandy soda*) is procured by the combustion of cryptogamic plants of the order

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[1] Knapp's *Chemical Technology*.

[2] Loudon, *Encyclopædia of Agriculture*.

[3] Lagasca, quoted in De Candolle's *Phys. Vég.* p. 388.

[4] *Cours d'Hist. Nat.* t. 2nde, p. 488.

[5] *A General Statement of the Imports and Exports*, printed by order of the House of Commons, 24th Feb. 1829.

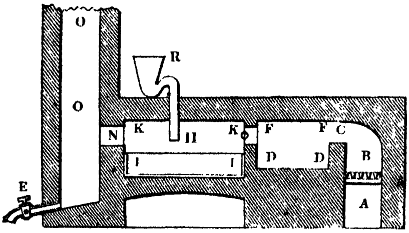
[6] *Trade List*, Jan. 5, 1841.

Algaceæ. According to Dr. Greville,[1] the species most valued for this purpose are Fucus vesiculosus, nodosus and serratus, Laminaria digitata and bulbosa, Himanthalia lorea, and Chorda Filum. These are burned in coffers of stone or in kilns. About 24 tons of sea-weed are required to produce one ton of kelp.[2] The resulting ash is kelp. As met with in commerce, it consists of hard, dark grey or bluish masses, which have an acrid, caustic taste, and are composed of *chloride of sodium*, about five per cent. of *carbonate of soda* (formed by the decomposition of the organic salts of soda), *sulphates of soda* and *potash, chloride of potassium, iodide of potassium* or *sodium*, and *insoluble* and *colouring matters*. By digesting kelp in a small quantity of water, and filtering and evaporating the solution, crystals of carbonate of soda may be procured. But as this salt can be procured at a lower price and of finer quality from artificial soda, kelp is now of little value as a source of soda. In the Orkney Islands, about 20,000 persons were, a few years since, occupied in the manufacture of it.[3]

3. *Artificial soda.*—This is obtained from sulphate of soda, or indirectly from common salt. The principal manufactories are situated in the northern parts of the kingdom, and are conducted on a most extensive scale. The process adopted varies in some of its details in different places; but it consists essentially in the conversion of common salt (chloride of sodium) into sulphate of soda, and the decomposition and conversion of this into carbonate of soda.

The sulphate of soda employed is in part obtained from manufacturers of chloride of lime, who procure a considerable quantity in the process for generating chlorine: but the greater part of it is made expressly by adding sulphuric acid to common salt (chloride of sodium). $NaCl + HO,SO^3 = NaO,SO^3 + HCl$. The hydrochloric acid gas evolved in this process is highly injurious to vegetable and animal life[4] (see *ante*, p. 376); and various contrivances have been resorted to to prevent its escape into the atmosphere, as by absorbing it by water or lime.

Fig. 88.



Furnace for converting Chloride of Sodium into Sulphate of Soda.

A. Ash-pit.
B. Grate.
C. Bridge.
D, D. First calcining hearth.
F, F. Its roof.
G. Second bridge.
I, I. Square lead pan.
K, K. Roof of decomposing hearth.
N. Third bridge.
O, O. Chimney filled with round flint nodules, kept continually moist by the trickling of a streamlet of water upon the topmost layer. The muriatic acid is absorbed by the water, and the solution escapes below at P.
R. Syphon funnel, by which the sulphuric acid is introduced.

The sulphate of soda, reduced to powder, is usually decomposed by mixing it with an equal weight of ground chalk (carbonate of lime) and half its weight of small coal ground and sifted, and heating the mixture in a very hot reverberatory furnace. During the operation it is frequently stirred. The product has a dark grey or blackish appearance, and is called *crude soda, British barilla, ball alkali,* or *black balls.* It consists essentially of carbonate of soda, caustic soda, and oxisulphuret of calcium.

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[1] *Algæ Britannicæ*, p. xxi.

[2] Macculloch's *Western Islands*, vol. i. p. 123.

[3] Greville, *op. cit.*

[4] A very humorous account of the unpleasant effects of this gas is contained in the report of a trial at Lancaster, March 21, 1838, the Queen *v.* Airey, in the *Times* newspaper.

In this process two consecutive changes occur: in the first place, the carbon of the coal deoxidizes the sulphate of soda, the products being carbonic oxide and sulphuret of sodium. $NaO,SO^3+4C=NaS+4CO$. In the second place, the sulphuret of sodium and carbonate of lime interchange their constituents, and give rise to carbonate of soda and sulphuret of calcium. $NaS+CaO,CO^2=NaO,CO^2+CaS$. But as a portion of the carbonate of lime has been burned or deprived of its carbonic acid before this interchange occurs, some caustic soda is also produced. $NaS+CaO=NaO+CaS$. To prevent, in the subsequent operation of lixiviation, the decomposition of the carbonate of soda by the sulphuret of calcium, twice as much carbonate of lime is used as is necessary to desulphurise the sulphuret of sodium: this excess of carbonate of lime is deprived of its carbonic acid by the heat, and the resulting lime combines with the sulphuret of calcium to form an oxysulphuret of calcium. $CaO+2CaS$. This has no further action on the sulphuret of sodium.

The following is the composition, according to Richardson, of the Newcastle "black balls" from the balling furnaces:—*Carbonate of soda* 9·89, *hydrate of soda* 25·64, *sulphuret of calcium* 35·57, *carbonate of lime* 15·67, *sulphate of soda* 3·64, *chloride of sodium* 0·60, *sulphuret of iron* 1·22, *silicate of magnesia* 0·88, *carbon* 4·28, *sand* 0·44, and *water* 2·17.

Ball alkali is ground to powder (*ground black balls*) and lixiviated with water, and the carbonate of soda and caustic soda thereby separated from the more difficultly soluble oxisulphuret of calcium. The solution, by evaporation, deposits crystals of monohydrated carbonate of soda, and the mother liquor yields a dark crystalline mass, composed of carbonate of soda, caustic soda, sulphuret of sodium, and some hyposulphite of soda (NaO,S^2O^2, formed by the oxidation of NaS). This is roasted in a reverberatory furnace, to get rid of the sulphur (probably in the form of sulphuretted hydrogen). Or it is calcined with coal-dust or saw-dust. The sulphate of soda is converted into sulphuret of sodium, and subsequently into carbonate of soda; and the caustic soda combines with carbonic acid. The product is called *soda-ash* or *soda-salts*, and contains about 50 per cent. of alkali.[1] From this crystallized carbonate of soda is obtained by lixiviating it with water, straining the solution, and evaporating. The salt is usually crystallized in iron pans.

PURIFICATION.—The London and Dublin Colleges give directions for the purification of the impure carbonate of soda of commerce.

The *London College* orders of impure Carbonate of Soda, lb. ij.; Distilled Water, Oiv. Boil the impure carbonate of soda in water, and strain it while hot. Lastly, set it by, that crystals may be formed.

The *Dublin College* directs Carbonate of Soda to be prepared from Barilla, in the same way. The operations are to be repeated until the crystals are sufficiently pure.

PROPERTIES.—Carbonate of soda usually forms large crystals, which are oblique rhombic prisms (figs. 89 and 90, p. 528). They are transparent,

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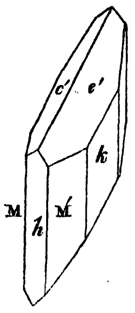
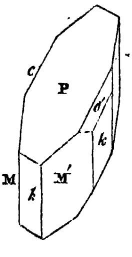
[1] For further details, consult Dumas, *Traité de Chimie*, t. ii.; Graham, *Elements of Chemistry*; Brande, *Manual of Chemistry*; Duncan, *Edinburgh Dispensatory*; Ure's *Dictionary of Arts*; and Knapp's *Chemical Technology*.

FIG. 89.



Ordinary Crystal.

FIG. 90.



Crystal reduced in height.

and have a cooling alkaline taste. By exposure to the air they effloresce. When heated they undergo the watery fusion, and give out their water of crystallization: at a red heat, the whole of the water is expelled. Carbonate of soda is insoluble in alcohol. It dissolves in twice its weight of water at 60°, and in less than its own weight at 212° F. The solution reacts as an alkali on vegetable colours.

Characteristics.—As a carbonate it is known by the tests for this class of salts already stated (see *ante*, p. 319). From the bicarbonate it is distinguished by the brick-red precipitate which it throws down with bichloride of mercury; and by sulphate of magnesia causing a white precipitate with it. As a soda salt it is recognised by the tests for soda already stated (see *ante*, p. 523).

COMPOSITION.—The perfect crystals of the ordinary carbonate of soda of commerce have the following composition:—

	Atoms.	*Eq. Wt.*	*Per Cent.*	*Klaproth.*	*Kirwan.*	*Bergman.*
Soda	1	31	21·68	22	21·58	20
Carbonic Acid	1	22	15·39	16	14·42	16
Water	10	90	62·93	62	64·00	64
Crystallized Carbonate of Soda	1	143	100·00	100	100·00	100

Four other crystallized monocarbonates of soda have been described: they contain respectively HO, $5HO$, $6HO$, and $8HO$ (L. Gmelin).

IMPURITY.—The ordinary impurities of this salt are sulphates and chlorides. These are detected as follows:—Supersaturate with nitric acid, and then add, to separate portions of the diluted solution, chloride of barium and nitrate of silver: if the first occasion a white precipitate, it indicates the presence of a sulphate—if the second also produce a white precipitate, soluble in ammonia, it shows the presence of a chloride.

The presence of hyposulphite of soda is detected by hydrochloric acid, which causes the evolution of sulphurous acid gas, and the precipitation of sulphur. Carbonate of lime and also carbonate of magnesia are sometimes kept in solution by carbonate of soda. If carbonate of lime be present, the solution deposits, at 32° F., a white crystalline powder, the hydrochloric solution of which yields a white precipitate with oxalate of ammonia.

When freshly prepared it [Crystallized Carbonate of Soda] is translucent, but in an open vessel it in a short time falls to powder. It is totally soluble in water, but not at all in alcohol. It alters the colour of turmeric like an alkali.—*Ph. L.*

"A solution of 21 grains in a fluidounce of distilled water, precipitated by 19 grains of nitrate of baryta, remains precipitable by more of the test; and the precipitate is entirely soluble in nitric acid. Little subject to adulteration."—*Ph. Ed.*

PHYSIOLOGICAL EFFECTS.—Carbonate of soda is less acrid and caustic, and has a milder and less unpleasant taste, than carbonate of potash; but in other respects the effects of these two salts on both vegetables and animals are similar.

USES.—Carbonate of soda is used in the same cases as carbonate of potash, over which it has the advantage of a less disagreeable taste. Fourcroy imagined that as soda is contained in animals in larger proportion than potash, it was a better agent for medicinal use. Experience, however, has not confirmed this opinion, but has proved the reverse; for both Sir G. Blane[1] and Mr. Brande[2] state that they obtained beneficial effects, in calculous complaints, from the use of potash, where soda failed to give any relief. Sir G. Blane accounted for this by assuming that soda becomes applied to the purposes of the economy before it reaches the kidneys, whereas potash is carried to these organs in order to be thrown out of the system.

ADMINISTRATION.—Crystallized carbonate of soda is exhibited in doses of from ten grains to half a drachm or a drachm. It is sometimes employed in the manufacture of the effervescing draught.

20 grains of Crystallized Carbonate of Soda are saturated by about	9¾ grs. of Commercial Crystals of Citric Acid. 10½ grs. of Crystals of Tartaric Acid. 2½ fluidrachms of Lemon Juice.

ANTIDOTES.—See antidotes for alkalies, p. 161.

SODÆ CARBONAS EXSICCATA, L. *Sodæ Carbonas siccatum*, E. D.; *Dried Carbonate of Soda*. Carbonate of Soda, lbj. Apply heat to the Carbonate of Soda in a proper vessel, until it is dried, and afterwards heat it to redness. Lastly, rub it to powder, *L.*—(The processes of the *Edinburgh* and *Dublin Colleges* are essentially the same). Fifty-three grains of this preparation are equal to one hundred and forty-three grains of the crystallized carbonate. It may be exhibited either in powder or pills. Dose from grs. v. to ℈j.

2. Sodæ Sesquicarbonas.—Sesquicarbonate of Soda.

Formula $2NaO,3CO^2$. *Equivalent Weight* 128.

HISTORY.—This salt was first distinguished from the monocarbonate of soda in 1802 by Klaproth.[3]

NATURAL HISTORY.—This salt occurs in the mineral kingdom. It is probably formed, at least in some cases, by the mutual action of common salt and carbonate of lime.[4]

1. In the province of Sukena near Tripoli, and two days' journey from Fezzan, there is found, at the bottom of a rocky mountain, a substance called by the Africans *trona* (a word from which probably the terms *νίτρον*, *nitrum*, and *natron* are derived). It forms thin crusts on the surface of the earth, which are rarely an inch in thickness.[5] The walls of Cassar (or Qasrr), a fort now in ruins, are said to have been built of it. This salt has been analysed both by Klaproth, Beudant,[6] and Mr. R. Phillips,[7] and found to be a sesquicarbonate of soda.

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[1] *Transactions of a Society for the Improvement of Med. and Chirurg. Knowledge*, iii. 347.

[2] *Quarterly Journal of Science*, vol. vi. p. 205.

[3] *Beiträge*, iii. 83.

[4] Berthollet, *Essai de Statique Chimique*, t. i. p. 400; and *Mém. sur l'Egypte.*

[5] Bagge, quoted by Jameson, *System of Mineralogy*, vol. ii. p. 315, 2d ed. 1816

[6] *Traité élément. de Mineralogie*, 2ème ed. t. ii. p. 313, 1832.

[7] *Quarterly Journal of Science*, vol. vii. p. 297.

2. At the bottom of a lake at Lagunillas, near Merida, in Venezuela, is found a substance called by the Indians *urao.* It is collected every two years by the natives, who, aided by a pole, plunge into the lake, separate the bed of earth which covers the mineral, break the urao, and rise with it to the surface of the water. It is placed in boats, removed to the magazine, and dried in the sun.[1] From the analysis of MM. Mariano de Rivero and Boussingault[2] its composition appears to be similar to trona.

3. Egyptian natron, deposited on the sides of several lakes to the west of the Delta of Egypt, consists of *carbonate of soda, sulphate of soda, common salt, water, sand,* and other impurities in varying proportions.

The carbonate of soda found in Egyptian natron contains, according to Poutet,[3] more carbonic acid than is found in the monocarbonate, but less than that contained in the sesquicarbonate. It is probably, therefore, monocarbonate (see *ante,* p. 524) mixed or combined with either sesquicarbonate or bicarbonate.

4. The carbonate of soda of the natron of Hungary, (to which reference has already been made, see *ante,* p. 524) is probably similar in constitution to that of Egyptian natron. And the same perhaps holds good with respect to Bohemian natron.

PREPARATION.—According to Phillips and H. Rose a crystallized sesquicarbonate of soda is deposited by boiling down and cooling a watery solution of the bicarbonate of soda. According to Hermann[4] it is formed by effervescence from masses of mixed carbonate and bicarbonate of soda.

PROPERTIES.—The crystals of trona belong to the oblique prismatic system. By heat, as well as by long boiling of its watery solution, the sesquicarbonate evolves one-third of its carbonic acid, and is converted into the monocarbonate.

COMPOSITION.—It is probable that there are two sesquicarbonates, one containing three, the other four atoms of water.

	Atoms.	*Eq. Wt.*	*Per Cent.*	*Hermann.*	*Winckler.*
Soda	2	62	40·00	40·00	41·13
Carbonic Acid	3	66	42·58	43·06	43·31
Water	3	27	17·42	16·94	15·56
Artificially prepared Sesquicarbonate	1	155	100·00	100·00	100·00

				Boussingault.	*Klaproth.*	*Beudant.* (Trona.)			*Phillips.*
	Atoms.	*Eq.Wt.*	*Per Ct.*	(Urao.)	(Trona.)	In agglom^d cryst.	In rad^s fibres.	Walls of Cassar.	(Artific^l Salt.)
Soda	2	62	37·805	41·22	37·0	37·428	38·62	32·67	39·72
Carb^c Acid	3	66	40·244	39·00	38·0	39·274	40·13	33·53	40·00
Water	4	36	21·951	18·80	22·5	23·287	21·24	20·55	20·28
	1	164	100·000	99·02	97·5	99·989	99·99	86·75	100·00
Foreign Matters				0·98	NaO,SO^3 2·5			NaO,SO^3 1·96 NaCl 3·95 Earthy matter 7·33	
				100·00	100·0			99·99	

It is probable that the so-called sesquicarbonate of soda is, in fact, a double salt composed of the monocarbonate and bicarbonate. (See *Ammoniæ Sesquicarbonas,* p. 439).

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[1] *Quarterly Journal of Science,* vol. i. p. 188.

[2] *Ann. de Chim. et Phys.* xxix. 110, 1825.

[3] *Journ. de Chim. Méd.* t. vi. p. 197, 1830.

[4] *Chemical Gazette,* vol. i. p. 142, 1843.

The white powder sold in the shops of this country for making *soda powders*, and which is denominated *carbonate*, *bicarbonate*, or *sesquicarbonate of soda* (*sodæ sesquicarbonas*, Ph. L.) consists either of bicarbonate of soda or of a mixture of carbonate and bicarbonate of soda, in varying proportions (see p. 533).

EFFECTS AND USES.—Similar to those of carbonate and bicarbonate of potash.

3. Sodæ Bicarbonas.—Bicarbonate of Soda.

Formula $NaO,2CO^2,HO$. *Equivalent Weight* 84.

HISTORY.—This salt was discovered by Valentine Rose. In some works it is termed *natron carbonicum perfecte saturatum seu acidulum*. Alone or mixed with carbonate of soda it constitutes the *sodæ sesquicarbonas* of the London Pharmacopœia,—the *carbonate* or *bicarbonate of soda* of the shops.

NATURAL HISTORY.—It is a constituent of the mineral waters called *alkaline* or *acidulo-alkaline*, as those of Carlsbad and Seltzer (see pp. 299 and 303).

PREPARATION.—Bicarbonate of soda is prepared by saturating the monocarbonate with carbonic acid. There are several methods of effecting this.

1. *By passing carbonic acid into a solution of the monocarbonate of soda.* This is the method ordered in the London and Dublin Pharmacopœias, and still followed at Apothecaries' Hall, London. The carbonic acid is usually obtained by the action of sulphuric acid on whiting. $CaO,CO^2 + HO,SO^3 = CaO,SO^3 + HO + CO^2$. In some countries, however, it is obtained from natural sources; as at Vichy, where it is collected from the mineral waters.[1]

At Apothecaries' Hall iron vessels are employed both for the generation of the carbonic acid and for holding the saline solution.

The *London College* orders the so-called sesquicarbonate to be prepared with Carbonate of Soda, lbvij.; Distilled Water, *Cong.* j. Dissolve the Carbonate of Soda in the Water, and strain; then pass Carbonic Acid into the solution to saturation, that the salt may subside. Wrapped and pressed in cloth, dry this with a gentle heat.

The *Dublin College* orders of Carbonate of Soda *two parts;* Water, *five parts.* Dissolve. Let the liquor be exposed in a suitable apparatus to the stream of Carbonic Acid gas, which escapes during the solution of white marble in diluted Muriatic Acid, until it shall have ceased to absorb gas, and let it rise until crystals form: then, with a heat not exceeding 120°, let the liquor evaporate and crystals be formed by cooling; these are to be mixed with the former, dried and preserved in a close vessel.

In the manufacture of bicarbonate of soda "for the purpose of commerce, 160 lbs. of carbonate may be dissolved in 13 gallons of water, and carbonic acid thrown into the solution in a proper apparatus. The bicarbonate falls, as it forms, to the amount of about 50 lbs., and, being separated from the solution, may be conveniently dried by pressure in an hydraulic press. A fresh portion of carbonate is dissolved in the mother liquor, and the operation repeated as before."[1] By this method of proceeding, a very pure bicarbonate is procured; but the objection to the process is its costliness.

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[1] For a description and sketch of the apparatus used in the collection of the gas by D'Arcet, see *Dict. de l'Indust.* 3me t. p. 61.

2. *By exposing solid monocarbonate of soda to an atmosphere of carbonic acid gas.*—This is the process ordered to be followed in the Edinburgh Pharmacopœia, and which is usually practised for obtaining the commercial bicarbonate. The monocarbonate rapidly absorbs carbonic acid under the development of heat, and becomes moist, owing to the evolution of part of the water of crystallization.

The *Edinburgh College* orders the bicarbonate to be prepared as follows:—Fill with fragments of marble a glass jar, open at the bottom and tubulated at the top; close the bottom in such a way as to keep in the marble without preventing the free passage of a fluid; connect the tubulature closely by a bent tube and corks with an empty bottle, and this in like manner with another bottle filled with one part of Carbonate of Soda, and two parts of Dried Carbonate of Soda, well triturated together; and let the tube be long enough to reach the bottom of the bottle. Before closing the last cork closely, immerse the jar to the top in diluted muriatic acid contained in any convenient vessel; when the whole apparatus is thus filled with carbonic acid gas, secure the last cork tightly, and let the action go on till next morning, or till gas is no longer absorbed by the salt. Remove the damp salt which is formed, and dry it, either in the air without heat, or at a temperature not above 120°.

The carbonic acid gas is sometimes developed by the action of hydrochloric acid (produced in the manufacture of carbonate of soda from common salt, see *ante*, p. 526) on chalk.[2]

Smith's process for the preparation of bicarbonate of soda consists in placing the ordinary carbonate of soda in a box, and surrounding it by an atmosphere of carbonic acid gas under pressure. As the bicarbonate combines with much less water of crystallization than is contained in the carbonate, a considerable portion of water is liberated, which, saturated with part of the salt, is allowed to drain off: when the gas ceases to be absorbed, the salt is taken out and dried. On examination, it is found to have retained the original form of the pieces; but they have become of a porous and loose texture, presenting the appearance of numerous crystalline grains aggregated together, and having a snow-white colour.[3] As, however, the monocarbonate readily absorbs carbonic acid, pressure is scarcely necessary.

The shelves or trays containing the monocarbonate are usually somewhat inclined, to allow the moisture to drain from the salt. When the carbonate has become fully saturated with carbonic acid, it is dried in stoves gently heated by iron pipes, and ground between stones, like flour, care being taken that the motion of the stones is too slow to prevent the evolution of much heat.

This process is the most economical one; but it is obvious that all, or nearly all, the impurity contained in the monocarbonate will be retained by the bicarbonate.

3. *By converting monocarbonate into bicarbonate of soda by means of sesquicarbonate of ammonia.*—In the London Pharmacopœia for 1809, it was ordered to be prepared by adding the hydrated sesquicarbonate of

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[1] Brande, *Manual of Chemistry*, 1848.

[2] Knapp's *Chemical Technology*.

[3] *Journ. of the Philadelphia College of Pharm.* vol. i., quoted by Dr. Bache, in the *United States Dispensatory*. For a sketch of the apparatus employed by Soubeiran, in performing Smith's process, see his *Nouv. Traité de Pharm.* t. 2me, pp. 289 and 284, 2nde éd. Paris, 1840.

ammonia to a solution of carbonate of soda, and applying a heat of about 100° F. to drive off the ammonia: the solution is then to be set aside to crystallize. The proportions of the ingredients employed were a pound of carbonate of soda, three ounces of sesquicarbonate of ammonia, and a pint of distilled water. Winckler[1] directs 4 parts of crystallized carbonate of soda, $1\frac{1}{2}$ parts of sesquicarbonate of ammonia, and 10 parts of water. The proportions ordered by MM. Henry and Guibourt[2] are 6 parts of the crystallized carbonate of soda, 2 parts of sesquicarbonate of ammonia, and 4 parts of water.

PROPERTIES.—Perfect crystals of bicarbonate of soda are, according to Dr. Thomson,[3] oblique rectangular prisms. By others they are described as four-sided tables. As usually met with in commerce, this salt is in the form of a whitish powder. In the latter state it is usually contaminated with a small portion of the carbonate. The taste of this salt is slightly alkaline. It restores the blue colour of reddened litmus-paper, but has no alkaline reaction on turmeric. By exposure to the air it effloresces superficially. When heated, it evolves carbonic acid and water, and becomes the anhydrous carbonate. It dissolves in 13 parts, according to V. Rose, or 8 parts, according to Berthollet, of cold water. By heat, the solution loses first one-quarter, and subsequently one-half of its carbonic acid.

Characteristics.—As a carbonate, it is recognised by the tests for this class of salts before mentioned (see *ante*, p. 319). As a soda-salt, it is known by the tests for soda (see *ante*, p. 523).

The bicarbonate is distinguished from the monocarbonate of soda by the following characters:—By its not reddening turmeric, by its more difficult solubility in water, by its causing neither a brick-red precipitate with the bichloride of mercury, nor a white precipitate with the sulphate of magnesia of the shops, and by the quantity of carbonic acid which it evolves when sulphuric acid is added to it.

COMPOSITION.—Crystallized bicarbonate of soda has the following composition:—

	Atoms.	*Eq.Wt.*	*Per Cent.*	*Stromeyer.*	*R. Smith.*	*Thomson.*	*Berzelius.*	*Schindler.*
Soda	1	31	36·90	37·06	37·82	37·64	89·26	89·31
Carbonic Acid	2	44	52·38	52·20	52·00	51·76		
Water	1	9	10·71	10·74	10·18	10·59	10·74	10·69
Cryst. Bicarb. Soda	1	84	100·00	100·00	100·00	100·00	100·00	100·00

According to the analyses of Berthollet and Berard, the crystals contain two equivalents of water.

The *pulverulent bicarbonate of soda* of the shops is usually a mixture of bicarbonate with some monocarbonate. "The proportion of alkali in bicarbonate of soda is 37·0 per cent., but the salt of commerce generally contains upwards of 40 per cent., owing to the presence of neutral carbonate in the state of protohydrate, which last salt may be separated by a small quantity of water" (Graham).

PURITY.—When quite pure, a moderately dilute solution of this salt occasions no precipitate with bichloride of platinum, perchloric acid, or tartaric acid, by which its freedom from potash is demonstrated. When supersaturated with pure nitric acid, it gives no precipitate with either chloride of barium or nitrate of silver, by which the absence of sulphates and chlorides is shewn.

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[1] *Lehrb. d. Pharm. Chemie*, 1er Th. S. 292.

[2] *Pharm. Raisonnée*, t. 2nde, p. 409, éd. 2nde.

[3] *Chem. of Inorg. Bodies*, vol. ii. p. 54.

To detect the presence of any monocarbonate of soda proceed thus:—Pour a small quantity of distilled water over the suspected salt; shake and allow the mixture to stand for a few minutes, and then pour off the clear solution. If now a very dilute solution of bichloride of mercury be added to the clear liquor no precipitate is produced if only the bicarbonate be present; if the solution be more concentrated, an opalescence or white precipitate is formed, which in a few minutes becomes red. If any monocarbonate or sesquicarbonate be present, a red precipitate is formed immediately on the addition of the bichloride.

It is totally dissolved by water. Neither chloride of platina nor sulphate of magnesia, unless heated, throws down any thing from this solution. By a strong fire it is converted into anhydrous carbonate of soda.—*Ph. Lond.*

"A solution in 40 parts of water does not give an orange precipitate with solution of corrosive sublimate."—*Ph. Ed.*

PHYSIOLOGICAL EFFECTS.—The effects of this salt are analogous to those of bicarbonate of potash, than which it has a somewhat less disagreeable taste and a slighter local action. It is less caustic and irritant than the carbonate of soda. Its remote or constitutional effects are analogous to those of the alkalines before noticed (see *ante*, p. 176.

USES.—It is employed as an *antacid* in those forms of dyspepsia which are attended with an inordinate quantity of acid in the stomach; as a *lithonlytic* in those kinds of lithiasis which are accompanied with an excessive secretion of uric acid and the urates; as a *resolvent* or *alterative* in certain forms of inflammation, in glandular affections, in syphilis, and scrofula; and as a *diuretic* in some dropsical complaints.

The principal consumption of bicarbonate of soda (*sodæ sesquicarbonas*, Ph. L.) is in the preparation of the effervescing draught, soda powders, and Seidlitz powders: in these the bicarbonate is mixed with a vegetable acid (either citric or tartaric, usually the latter). Taken in a state of effervescence, a solution of this kind is an agreeable and refreshing drink for allaying thirst, checking sickness, and diminishing febrile heat (see *ante*, pp. 321 and 479). The resulting soda-salt (tartrate or citrate) undergoes partial digestion in its passage through the system, and is converted into carbonate, which is found in the urine (see *ante*, p. 180). Hence, therefore, these effervescing preparations may be employed as diuretics and lithonlytics, instead of the simple carbonate or bicarbonate of soda, than which they are more agreeable. On the other hand they are highly objectionable, and are to be carefully avoided, in the treatment of phosphatic deposits in the urine. Alluding to these cases, Dr. Prout[1] observes, "were I required to name the remedy calculated to do the most mischief, I should name the common saline draught, formed of potash or soda, and *some vegetable acid.*"

ADMINISTRATION.—The dose of this salt is from ten grains to a drachm. In the preparation of effervescing draughts, a scruple of the powder sold in the shops as bicarbonate of soda (*sodæ sesquicarbonas*, Ph. L.) usually requires about 18 grains of crystallized tartaric acid, or about 17 grains of the ordinary crystals of citric acid, or four fluidrachms of lemon juice, to saturate it.

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[1] *Inquiry into the Nature and Treatment of Affections of the Urinary Organs*, 2d ed. p. 145.

1. PULVERES EFFERVESCENTES, E. *Effervescing Powders. Pulvis gas carbonicum evolvens.* Ph. Ruth. (Tartaric Acid, ℥j.; Bicarbonate of Soda, ℥j. and grs. liv.; or, Bicarbonate of Potash, ℥j. and grs. clx. Reduce the acid and either bicarbonate separately to fine powder, and divide each into sixteen powders; preserve the acid and alkaline powders in separate papers of different colours.)

The *Soda Powders* of the shops consist of 30 grains of bicarbonate of soda, contained in a blue paper, and 25 grains of tartaric acid, in a white paper. When taken they should be dissolved in half a pint of water. The flavour of the solution is improved by adding to the water, before dissolving the acid, one or two drachms of simple syrup, and either half a drachm of the tincture of orange-peel, or two or three drops of the essence of lemon.

Ginger Beer powders (*pulveres effervescentes cum zingibere*) are sometimes made as soda powders with the addition of five grains of powdered ginger and a drachm of powdered white sugar. Another and a better formula is the following:—White Sugar, ʒij.; Bicarbonate of Soda, gr. xxvi.; Powdered Ginger, grs. v.; Essence of Lemon, gtt. j. Mix, and put in white paper. The blue paper contains powder of tartaric acid, ʒss.

2. PULVERES SEDLITZENSES, *Seidlitz Powders.*—These consist of two drachms of Tartarized Soda and two scruples of Bicarbonate of Soda contained in a blue paper, and half a drachm of powdered Tartaric Acid in a white paper. These are to be taken dissolved in half a pint of water, while the liquid is in a state of effervescence. These form an agreeable and mild aperient. Why they are called *Seidlitz* powders I cannot understand, since they have no analogy to constituents of Seidlitz water.

3. LIQUOR SODÆ EFFERVESCENS, L. *Sodæ Aqua Effervescens,* E; *Aqua Carbonatis Sodæ Acidula,* D.; *Effervescing Solution of Supercarbonate of Soda; Soda Water, properly so called.* (Sesquicarbonate [Bicarbonate, *E.*] of Soda, ʒj.; Distilled Water, Oj. Dissolve the carbonate in the water, and pass into it, compressed by force, more carbonic acid than is sufficient for saturation. Keep the solution in a well-stoppered bottle, *L. E.*—The process of the Dublin Pharmacopœia is essentially similar, except that carbonate of soda is substituted for the bicarbonate).—This solution is employed in the same cases as bicarbonate of soda. The additional quantity of carbonic acid contained in it renders it more agreeable, and not less effectual, as an alkaline agent, in its operation on the system generally. It is employed to counteract or prevent the inordinate secretion of uric acid and the urates; but both this and soda water powders are highly injurious in phosphatic deposits (see p. 534).

The *Bottled Soda Water* of the shops is in general only carbonic acid water (see *ante,* p. 324). *Webb's Soda Water* contains 15 grains of crystallized carbonate of soda in each bottle. If, after it has ceased to effervesce, tartaric acid be added to bottle soda water, the effervescence is not renewed unless an alkaline carbonate be present.

Liquor sodæ effervescens may be extemporaneously made by pouring carbonic acid water into a tumbler containing half a drachm of bicarbonate of soda.

A fraudulent imitation of soda water is said to have been practised, by adding a few drops of sulphuric acid to a solution of carbonate of soda in water, and instantly corking the bottle. The fraud may be detected by chloride of barium, which throws down a white precipitate insoluble in nitric acid.

4. **SODÆ CARBONATIS AQUA,** D. *Solution of Carbonate of Soda.* (Take of Carbonate of Soda any required quantity; dissolve in water, and let the specific gravity of the liquor be to that of distilled water as 1024 to 1000. A liquor of the same specific gravity is prepared by dissolving an ounce of [crystallized] carbonate of soda in a [wine] pint of distilled water). Dose from fʒiij. to f℥ij.

5. **TROCHISCI SODÆ BICARBONATIS,** E. *Soda Lozenges.* (Bicarbonate of Soda, ℥j.; Pure Sugar, ℥iij.; Gum Arabic, ℥ss. Pulverise them, and, with mucilage, beat them into a proper mass for making lozenges). Employed to relieve too great acidity of stomach.

58. SODÆ BIBORAS.—BIBORATE OF SODA OR BORAX.

Formula $NaO,2BO^3$. *Equivalent Weight* 101.

HISTORY.—The word *borax* is derived from the Arabic *baurak* (also written *baurach*), a term applied by the Arabians to the νίτρον or *nitrum* of the Greeks and Romans (see *ante*, p. 516). It is probable that when the Arabians first became acquainted with our borax, they considered it as a kind of nitrum. Subsequently, however, when the difference between nitrum and biborate of soda became known in Europe, the latter exclusively retained the name of borax.[1] It is probable that the baurak of Geber[2] was our borax.

Perhaps the artificial *chrysocolla* (χρυσόκολλα, *gold-solder*) alluded to by Pliny,[3] and which, he says, was used as a gold-solder (*auri glutinum*), and was termed *santerna*, contained borax.

In modern times borax has been termed *borate, sub-borate,* or *biborate of soda* (*sodæ boras, sub-boras,* vel *biboras*), according to the presumed atomic weight of boracic acid.

NATURAL HISTORY.—Borax is a substance peculiar to the mineral kingdom. It has been found in some mineral waters, as those of San Restituta, in Ischia.[4] It occurs also in the waters of certain lakes, especially those of Thibet and Persia.

About fifteen days' journey north from Teeshoo Lomboo [Tissoolumboo], in Thibet, is a lake, said to be about twenty miles in circumference, and supplied by brackish springs rising from the bottom of the lake itself. In consequence of its high situation, during a part of the year this lake is frozen over. The water of it contains in solution both common salt and borax. The latter crystallizes on the edges and shallows of the lake, and is taken up in large masses, which are broken and dried.[5] It is stated that the natives mix it with an earth thinly covered with butter, to prevent the borax evaporating![1] It is imported, usually from Calcutta, under the name of *tincal* (*tinkar*, Persian; from *tincana*, the Sanscrit name for borax,[2] or *crude borax* (*borax cruda* seu *nativa*), in the form of flattened six-sided prisms, coloured with a greasy unctuous substance, said by Vauquelin to be a fatty matter saponified by soda: the colour is yellowish, bluish, or greenish. Mojon states that the greenish-grey matter which surrounds some kinds of rough borax, contains native boron.

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[1] Beckmann's *History of Inventions*, vol. iv. p. 559, 1814.

[2] *Search of Perfection*, ch. iii.

[3] *Hist. Nat.* lib. xxxiii. cap. 29.—For some remarks on *chrysocolla*, see Adams's translation of Paulus Ægineta, vol. iii. p. 415.

[4] Gairdner, *On Mineral Springs*, p. 414.

[5] Turner's *Account of an Embassy to the Court of Teshoo Lama, in Thibet*, p. 406, Lond. 1800.

Borax of a superior quality is said to be procured in China,[3] where it is called *pong-cha* or *pounxa*.[4] *Zala* and *swaga* (*sohaga*, Hindostanee) are said to be Thibetan names for this salt (Leonhard).

PREPARATION.—Commercial borax is obtained either by the purification of native borax (tincal), or by saturating boracic acid with soda.

1. *By refining tincal.*—The method of purifying tincal, or native borax, has always been kept as secret as possible. It was formerly practised at Venice; and hence refined borax was called *Venetian borax* (*borax veneta*). Afterwards it was practised at Amsterdam.

In order to destroy the fatty or saponaceous matter which coats the crystals of tincal, some manufacturers, it is said, calcine them, and afterwards dissolve and crystallize the salt.

Another method is to wash the crystals several times with cold water, to which some lime has been added; dissolve the washed crystals in hot water, to which some chloride of calcium has been added; strain, evaporate, and crystallize. By the reaction of the chloride of calcium on the soapy matter, there are formed some chloride of sodium in solution, and an insoluble calcareous soap, which is got rid of by filtration.

A third method of purifying tincal is to wash the crystals with a solution of caustic soda. Dissolve the washed crystals in water, add some caustic soda to the solution to precipitate the earthy matters, decant and evaporate the clear solution so as to obtain crystals.

Borax is usually crystallized in wooden vessels lined with lead, and which have the form of short inverted cones. Borax thus purified is called *refined borax* (*borax depurata* seu *purificata*).

2. *By saturating native boracic acid with soda.*—The mode of preparing boracic acid in Tuscany has been already described (see *ante*, p. 325). The rough or crude acid usually contains from 17 to 20, or more, per cent. of impurities. It is converted into borax in the following way:—Dissolve carbonate of soda in water contained in tubs lined with lead and heated by steam. Add coarsely pulverised boracic acid. The evolved gas is passed through sulphuric acid, to detain any carbonate of ammonia which may be contained in it. Boil the liquor, and let it stand for ten or twelve hours. Then draw it off into wooden crystallizing vessels lined with lead. Here *rough* or *crude borax* is deposited. This is refined by dissolving it in water, contained in a tub lined with lead and heated by steam; adding more carbonate of soda, and crystallizing. The crystals are allowed to drain, and when dry are packed in chests. In this way is obtained *common* or *prismatic borax*.

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[1] Anderson's periodical called *The Bee*, vol. xvii. p. 22, Edinb. 1793.
[2] Royle's *Essay on the Antiquity of Hindoo Medicine*, p. 23.
[3] Ainslie's *Materia Medica*, vol. i. p. 45.
[4] Leonhard, *Handb. der Oryktognosie*, 1826.

Octohedral borax is obtained by employing more concentrated solutions: it deposits at from 174° to 133° F.[1]

Sautter has patented a dry process for preparing borax. It consists in mixing 38 parts of pure dry boracic acid with 45 parts of crystallized carbonate of soda, and placing the mixture upon wooden shelves in a heated room. The boracic acid expels the carbonic acid and some water, and combines with the soda.[2]

PROPERTIES.—It usually occurs in large, colourless, transparent prisms, belonging to the oblique prismatic system (*prismatic borax*), $NaO,2BO^3,10HO$. It also occurs in octohedrons (*octohedral borax*), $NaO,2BO^3,5HO$. In commerce, we frequently meet with it in irregular-shaped masses. Its taste is saline, cooling, and somewhat alkaline. It reacts on turmeric paper like an alkali. By exposure to the air, it effloresces slowly and slightly. When heated, it melts in its water of crystallization, swells up, and forms a light, white, porous substance, called *calcined borax* (*borax usta* seu *calcinata*). At a higher temperature it fuses into a transparent glass, called *glass of borax* (*borax vitrificata*), which is anhydrous borax, $Na2BO^3$. It is soluble in twelve parts of cold, or in two parts of hot water.

Characteristics.—Borax may be recognised by the following characters:—It reddens turmeric paper; it fuses before the blowpipe into a glass, which may be readily tinged by various metallic solutions; thus, rose red by terchloride of gold, and blue by solutions of cobalt: if a few drops of sulphuric acid be added to powdered borax, and then spirit of wine, the latter will, when fired, burn with a green-coloured flame; lastly, if, to a strong hot solution of borax, sulphuric acid be added, boracic acid will be deposited in crystals as the liquid cools (see *ante*, pp. 327-8). The tests now mentioned for the most part only prove the salt to be a borate: the nature of the base is determinable by the tests for soda, before described (see *ante*, p. 523).

COMPOSITION.—The following is the composition of borax:—

	Atoms.	*Eq. Wt.*	*Per Cent.*	*Berzelius.*	*L. Gmelin.*	*Kirwan.*
Soda	1	31	16·23	16·31	17·8	17
Boracic Acid	2	70	36·65	36·59	35·6	34
Water	10	90	47·12	47·10	46·6	49
Crystallized Prismatic or Common Borax	1	191	100·00	100·00	100·0	100

Octohedral borax contains only five equivalents of water, $NaO,2BO^3,5HO$. It offers several advantages in the arts over the prismatic variety.[3]

PHYSIOLOGICAL EFFECTS.—The effects of borax have been imperfectly ascertained. Its *local* action is that of a mild irritant and chemical agent: applied to sores, it excites smarting, and, taken into the stomach in large doses, causes vomiting.

The *constitutional effects* are probably those of a mild refrigerant and diuretic. Wöhler and Stehberger detected it in the urine (see *ante*, p. 101), so that it passes out of the system unchanged.

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[1] Payen, *Ann. de Chim. et de Physique*, 3me Sér. tome ii. p. 322, Juillet 1841; also Knapp's *Chemical Technology*.

[2] Knapp's *Chemical Technology*.

[3] Guibourt, *Hist. des Drog.* t. i. p. 191, éd. 3me.

Borax is usually regarded as an agent exercising a specific influence over the uterus; promoting menstruation, alleviating the pain which sometimes attends this process, facilitating parturition, diminishing the pain of accouchement, and favouring the expulsion of the placenta and lochia.[1] It has also been termed an aphrodisiac.[2]

Borax has also been regarded as producing the effects of alkalies on the system.[3] When Homberg asserted that boracic acid was a sedative (see *ante*, p. 328), borax was supposed to possess similar properties.

After the present article was in type and the proof corrected, I received Dr. Buchner's *Repertorium für die Pharmacie*, Bd. xlix. Heft 1 and 2, 1848, containing Dr. Binswanger's prize essay on boracic acid and borax, as well as on other borates.

It appears that in 1844 the Medical Faculty of Munich offered, as the subject of a prize essay, the pharmacological properties of boracic acid and borax. Three papers were sent in, one by Dr. Binswanger, to which the Academic prize was adjudged; a second by Dr. Mückel, to which another prize was given; and a third by Dr. Flügel.

I am only able to give a short abstract of Dr. Binswanger's conclusions, drawn from his physiological and chemical experiments.

1. *Boracic Acid.*—Possesses very slight physiological properties. In doses of from ʒj. to ʒiij. it occasions a feeling of oppression at the stomach, eructation, nausea, and even vomiting. In smaller doses it becomes speedily absorbed, and is eliminated by the kidneys, whose secretion it promotes. As a medicine it has less value than carbonic acid, to which it is analogous.

2. *Borax.*—In a pharmacological point of view, this salt resembles carbonate or bicarbonate of soda. Like the carbonate it has an alkaline reaction, acts as an antacid, and, when in solution, absorbs carbonic acid, and dissolves fibrine, albumen, casein, and uric acid. Swallowed in large doses it occasions oppression of stomach, nausea, and vomiting. It becomes absorbed, and is afterwards eliminated by the kidneys and other secreting organs. Binswanger detected it in the blood of the portal vein, in the bile and the saliva. It has, therefore, doubtless an influence on the process of chymification. In very large and repeated doses it produces the injurious effects of the alkalies: as inflammation of the stomach and bowels, disordered digestion, and a scorbutic condition. On Binswanger himself the use of it caused an impetiginous eruption. The author asserts that borax has no peculiar specific effect on the nervous system, sexual organs, or mucous surfaces. It has no specific power of exciting uterine contractions, of promoting menstruation, or of curing aphthous affections; though, like the carbonated alkalies, it may, by relaxing muscular fibres, slightly relieve spasm of the uterus, or, by its liquefacient properties, promote the evacuation of menstrual blood, or by its mild alkaline qualities improve the condition of the skin and mucous surfaces. As a lithonlytic for uric acid, Binswanger considers it more useful than any other salt; for, though its solvent power for this acid is inferior to that of carbonate of lithia, the rarity of the latter salt renders it less available. Borax acts as a solvent for uric acid, by yielding up part of its soda to form the soluble urate of soda; but it has no power of preventing the formation of this acid: it acts merely as a lithonlytic, that is, as a solvent for the already formed acid.

4. The *borate of potash* and the *borate of ammonia* resemble borax in their action on the system.

5. *Tartaras boraxatus* (see *ante*, p. 521) resembles bitartrate of potash, than which it is somewhat stronger, because it is more soluble.

USES.—As a *local agent*, borax is employed as a detergent in aphthæ and ulceration of the mouth. In some skin diseases it has been used with great benefit. In pityriasis versicolor (called also *liver spots* or *chloasma*), a strong solution of borax (as ℥ss. of borax to f℥viij. of water) is a most valuable remedy. It should be applied by a sponge or rag. A solution of ʒss. of borax in f℥viij. of rose-water is sometimes employed as an useful cosmetic. In gonorrhœa and leucorrhœa an aqueous solution has been occasionally used as an injection with success. *Unguentum boracis* (composed of ʒj. of borax to ℥j. of lard) has been applied to inflamed and painful hemorrhoidal tumors and to cracked nipples.

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[1] J. F. Meticke *De Virtute Boracis*. Diss. inaug. Med., Jenæ, 1784; Vogt's *Pharmakodynamik*; Dr. Copland, *Dict. of Pract. Med.* art. *Abortion*.

[2] Virey, *Bull. de Pharmacie*, t. v. p. 200, 1813.

[3] Vogt, *op. cit.*; and Sundelin, *Heilmittellehre*.

Internally, it has been used as a lithonlytic (see *ante*, p. 260); to act as a diuretic in dropsical affections; and to influence the uterus in the cases before mentioned. Dr. Copland recommends it, in conjunction with ergot of rye, to promote uterine contractions. I have occasionally employed it in amenorrhœa, but with doubtful success.

ADMINISTRATION.—The dose of it is from half a drachm to a drachm. As a detergent in aphthæ, it may be used in powder, mixed with sugar or with honey.

MEL BORACIS, L. E. D.; *Honey of Borax; Mellite of Borax.* (Borax, powdered, ʒj.; Honey [clarified, *L. D.*] ℥j. Mix.)—A convenient form for the employment of borax in the aphthæ of children. Dissolved in water, it may be employed as a gargle in ulceration of the mouth and throat.

59. SODÆ PHOSPHAS.—PHOSPHATE OF SODA.

Formula $\mathrm{HO,2NaO,}c\mathrm{PO^5+24HO}$. *Equivalent Weight* 359.

HISTORY.—This salt was long known before its true nature was understood. In 1737, it was noticed by Hellot, who detected it in the urine. In 1740, Haupt described it under the name of *sal mirabile perlatum*, or *wonderful perlated salt* (called *perlated*, from the pearl-like appearance which it assumed when melted by the blow-pipe). Rouelle, Jun., in 1776, and Klaproth, in 1785, showed that it was a compound of phosphoric acid and soda. It was introduced into medicine, as a purgative, by Dr. George Pearson.

It has had various names besides the one above mentioned. As it exists ready formed in the urine, it has been called *sal urinæ humanæ nativum.* It was formerly termed the *alcali minerale phosphoratum.* In the shops it is commonly called *tasteless purging salt*, or simply *tasteless salt.* To distinguish it from the other compounds of phosphoric acid and soda, it is frequently termed the *common* or *rhombic phosphate of soda*, and not unfrequently the *neutral phosphate of soda.* It has also been called the *triphosphate of soda and basic water.*

NATURAL HISTORY.—Phosphate of soda occurs in both kingdoms of nature.

α. IN THE INORGANISED KINGDOM.—It is a constituent of some mineral waters; viz. those of Steinbad at Töplitz, of Geilnau, Fachingen, Selters, and Neundorf.[1]

β. IN THE ORGANISED KINGDOM.—It is found in the ashes of plants.[2] It is a constituent of some animal fluids, as the blood and urine. According to Liebig,[3] the blood owes its alkaline quality, and its powers of absorbing and of giving off again carbonic acid, to this salt.

PREPARATION.—The Edinburgh and Dublin Colleges give each a formula for its preparation. The London College admits it as an article of the Materia Medica; that is, to be bought ready prepared.

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[1] Gairdner, *On Mineral Springs*, p. 19.

[2] Johnson, *Lectures on Agricultural Chemistry*, p. 331, 2d edit. 1847.

[3] *Researches on the Chemistry of Food*, pp. 116 and 117.

The *Edinburgh College* orders of Bones burnt to whiteness, lbx.; Sulphuric Acid, Oij. and f℥iv.; Carbonate of Soda, a sufficiency; Pulverize the bones and mix them with the acid; add gradually six pints of water; digest for three days, replacing the water which evaporates; add six pints of boiling water, and strain through strong linen; pass more boiling water through the mass on the filter till it comes away nearly tasteless. Let the impurities subside in the united liquors, pour off the clear fluid, and concentrate to six pints. Let the impurities again settle; and to the clear liquor, which is to be poured off and heated to ebullition, add carbonate of soda, previously dissolved in boiling water, until the acid is completely neutralized. Set the solution aside to cool and crystallize. More crystals will be obtained by successively evaporating, adding a little carbonate of soda till the liquid exerts a feeble alkaline reaction on [reddened] litmus paper, and then allowing it to cool. Preserve the crystals in well-closed vessels.

The *Dublin College* orders of Bone Ashes, reduced to powder, *ten parts;* Sulphuric Acid, of commerce, *seven parts;* and carbonate of soda, dissolved in hot water, *eight parts.* The directions for conducting the process are essentially the same as those of the Edinburgh College.

The products obtained by the mutual reaction of sulphuric acid and bone-ash are carbonic acid, sulphate of lime and a soluble superphosphate of lime (see *ante*, p. 329); the latter remains in solution, while the second is, for the most part, precipitated. On the addition of carbonate of soda to the liquor, phosphate of soda is formed in solution, subphosphate of lime is precipitated, and carbonic acid gas escapes. A slight excess of carbonate of soda promotes the formation of crystals of phosphate.

PROPERTIES.—This salt crystallizes in oblique rhombic prisms belonging to the oblique prismatic system (see *ante*, p. 142). The crystals are transparent, but by exposure to the air effloresce and become opaque. Their taste is cooling saline. They react feebly on vegetable colour like alkalies. When heated, they undergo the watery fusion, give out both their basic water and water of crystallization, and form a white mass called *pyrophosphate of soda:* ($2NaO,6bPO^5$). The crystals of phosphate of soda require, for their solution, four times their weight of cold or twice their weight of hot water: they are nearly insoluble in alcohol.

Characteristics.—As a soda-salt it is known by the tests for this base already mentioned (see *ante*, p. 523). As a tribasic phosphate its characteristics have been already stated (see *ante*, p. 335 and 336). Another character by which this salt is known is its crystalline form.

COMPOSITION.—The following is the composition of this salt:—

	Atoms.	*Eq. Wt.*	*Per Cent.*	*Berzelius.*	*Clark.*	*Graham.*	*Malaguti.*
Soda	2	62	17·270	17·67	37·48	37·1	16·71
Tribasic Phosphoric Acid	1	72	20·056	20·33			18·80
Basic Water	1	9	2·507	62·00	2·49	62·9	64·25
Water of Crystallization	24	216	60·167		60·03		
Crystallized Rhombic Phosphate of Soda	1	359	100·000	100·00	100·00	100·0	99·76

If this salt be dissolved in water and the solution evaporated at a temperature of 90°, it crystallizes with only fourteen atoms of water of crystallization. $HO,2NaO,cPO^5,14HO$.

IMPURITY.—As met with in commerce, phosphate of soda is usually tolerably pure.

Exposed to the air it slightly effloresces. It is totally dissolved by water, but not by alcohol. What is thrown down from the solution by chloride of barium is white: the precipitate by nitrate of silver is yellow, unless the phosphate has been previously made red hot. Both precipitates are soluble in nitric acid.—*Ph. Lond.*

If the precipitate caused by the chloride of barium be not totally soluble in nitric acid, a sulphate is present. If that caused by nitrate of silver do not entirely dissolve in nitric acid, a chloride is present.

"An efflorescent salt: 45 grains dissolved in two fluidounces of boiling distilled water, and precipitated by a solution of 50 grains of carbonate of lead in a fluidounce of pyroligneous acid, will remain precipitable by solution of acetate of lead."—*Ph. Ed.*

PHYSIOLOGICAL EFFECTS.—In doses of an ounce, or an ounce and a half, it acts as a mild antiphlogistic purgative, like sulphate of soda.

In smaller doses it operates like other saline substances (see *ante*, p. 178). Being an important and essential constituent of the healthy blood, it has been supposed that this salt would be less obnoxious to the organism than those salines which are not constituents of the body, and that it would pass into the system more readily. Moreover, some benefit has been expected from its influence as an agent acting on the blood, sometimes supplying a deficient ingredient and modifying its crasis. Furthermore, in diseases of perverted nutrition in which there is a deficiency of phosphates in the tissues, and in maladies in which the urine is deficient in phosphates, this salt has been employed with the view of supplying to the system one of its normal and apparently deficient constituents. Most of these notions, however, are hypothetical, and have not been supported by experience.

USES.—As a purgative it has been employed in the diseases of children and delicate persons, in preference to other saline substances, on account of its slight taste and mild action on the stomach. It is well adapted for febrile and inflammatory disorders.

It is one of the substances which have been employed in cholera, to restore to the blood its deficient saline matters[1] (see *ante*, p. 181).

On account of its supplying phosphoric acid, it has been supposed to be particularly applicable in those diseases in which there is a deficiency of phosphate of lime in the bones. Now there are two distinct diseases in which there is a deficiency of earthy matter in the bones; viz., rachitis, in which there is a defective deposition of phosphate of lime; and mollities ossium, in which the calcareous phosphate has been absorbed. In neither of these maladies, however, is there any evidence that the prime cause is a deficiency of material in the system: it seems referable rather to perverted vital action; and there is no evidence that this has been relieved by the use of phosphate of soda.

It has also been administered in diabetes. It has been resorted to for the purpose of supplying the system with an ingredient in which it was supposed to be deficient. For in this malady the phosphates of the urine are stated to be diminished. Simon,[2] however, declares that the amount of earthy phosphates in diabetic urine is not much below the normal average. Nicolas, Gueudeville,[3] Dr. Latham,[4] and Dr. Sharkey,[5] have employed phosphate of soda in diabetes with asserted benefit. It is said to promote the healthy action of the stomach, to keep the bowels regular, and to lessen the discharge of urine.

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[1] Dr. O'Shaughnessy, *Report on the Chemical Pathology of the Malignant Cholera*, p. 54.

[2] *Animal Chemistry*, vol. ii. p. 294.

[3] Nicolas et Gueudeville, *Recherches et Expériences Médicales sur la Diabète Sucrée*, Paris, 1803.

[4] *Facts and Opinions concerning Diabetes*, Lond. 1811.

[5] *Transactions of the Association of Fellows and Licentiates of the King and Queen's College of Physicians in Ireland*, vol. iv. p. 379.

Phosphate of soda is one of the substances which have been employed as a solvent for lithic acid calculi (see *ante*, p. 260).

ADMINISTRATION.—As a purgative, it is given in doses of from six to twelve drachms. It is best taken in broth or soup. As an alterative, the dose is one or two scruples three or four times a day.

SOLUTIO SODÆ PHOSPHATIS, E.; *Solution of Phosphate of Soda.* (Phosphate of Soda [free of efflorescence], grs. clxxv.; Distilled Water, f℥viij. Dissolve the salt in the water, and keep the solution in well-closed bottles).—Used only as a test.

Phosphate of soda is principally valuable as a test for magnesia (see *Magnesia*). It is also used to precipitate certain metallic oxides, especially oxide of lead (see *Lithargyrum, Plumbi Acetas,* and *Plumbi Carbonas*).

60. Sodæ Hyposulphis.—Hyposulphite of Soda.

Formula NaO,S^2O^2. *Equivalent Weight* 79.

Hyposulphis natricus seu *sodicus; Sulphis sodæ sulphuratus.*—First noticed by Chaussier[1] in 1799. In the French Codex for 1839, the following directions are given for the preparation of this salt:—Take of Crystallized Carbonate of Soda, 320 parts; Distilled Water, 640 parts; Sublimed Sulphur, 40 parts. Dissolve the carbonate in the water, add the sulphur, and pass a stream of sulphurous acid through the solution. When the gas shall be in excess in the liquor, hyposulphite of soda is in solution. Then boil for a few minutes, filter, evaporate by a gentle heat to a third of its volume, and set aside in a cool place, that crystals may form.—In this process carbonic acid is evolved, and the hyposulphite of soda formed in solution. $NaO,CO^2 + SO^2 + S = NaO,S^2O^2 + CO^2$.—There are several other methods of preparing this salt. The following is given by Walchner[2] as a ready mode of preparing it:—Pure crystallized carbonate of soda is dried as much as possible, and reduced to a fine powder; 1 lb. of it is then mixed with 10 oz. of flowers of sulphur, and the mixture heated in a glass or porcelain dish gradually, until the sulphur melts. The mass, which cakes together, is kept at this temperature, and is divided, stirred, and mixed, in order that each part may be brought into contact with the atmosphere. The sulphuret of sodium formed passes, under these circumstances, by the absorption of oxygen from the atmosphere, with a slight incandescence, gradually into sulphite of soda. It is dissolved in water, filtered, and the liquid immediately boiled with flowers of sulphur: the filtered, nearly colourless, strongly concentrated liquid affords hyposulphite of soda in very pure and beautiful crystals, and in large quantity.

According to Mitscherlich, hyposulphite of soda crystallizes from a hot, watery solution without any water of crystallization, NaO,S^2O^2; but from a less concentrated solution it separates in large, transparent, oblique prisms composed of $NaO,S^2O^2,5HO$. The crystals are odourless, and have a cool, afterwards bitter, taste. They readily dissolve in water, but not in alcohol. If sulphuric acid be added to a solution of this salt, sulphurous acid is disengaged, and sulphur precipitated. With nitrate of silver the hyposulphite of soda yields a white precipitate (AgO,S^2O^2), which ultimately becomes black, owing to its conversion into sulphuret of silver, AgS (which precipitates), and sulphuric acid, SO^3 (which remains in solution). Its power of dissolving chloride of silver, as well as other argentine compounds, has led to its use in the Daguerreotype process.

Hyposulphite of soda operates as a resolvent, alterative, and sudorific. It was first employed in medicine by Chaussier, and afterwards by Cazenave, Pleischl, Van Mons, Ravizza, and others. It has been used as a substitute for the natural sulphureous waters

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[1] *Journal de la Société des Pharmaciens de Paris,* tom. i. p. 406, 4to. Nov. 1799.

[2] *Chemical Gazette,* vol. i. p. 524, 1843.

(see *ante*, p. 298); in chronic cutaneous maladies (acne, porrigo, &c.) and visceral affections caused by their metastasis; in secondary syphilis; in gouty, rheumatic, and hæmorrhoidal affections; and in biliary calculi, on which this salt is said to have a solvent action.

The hyposulphite is employed internally in pills, or in aqueous solution, in doses of from ℈ij. to ʒj. Externally, it is used, dissolved in water, for the preparation of lotions and baths.

1. SYRUPUS SODÆ HYPOSULPHITIS; *Syrup of the Hyposulphite of Soda; Syrupus Natri Hyposulphurosi.*—Hyposulphite of soda, ℥j; Water, f℥xij.; Sugar, ℥xxiij. Dissolve with a gentle heat, and filter (Beasley).—Dose, ʒj. to ʒij.

2. BALNEUM SODÆ HYPOSULPHITIS; *Hyposulphite of Soda Bath.*—This is prepared by dissolving from ℥j. to ℥iv. (according to circumstances) of the hyposulphite of soda in a sufficiency of water to form a bath, which is sometimes employed as an artificial sulphur bath. Sometimes a small quantity of dilute sulphuric acid or of vinegar is added to the bath while the patient is immersed, by which sulphurous acid and sulphur are set free.

61. Sodæ Bisulphis.—Bisulphite of Soda.

Two compounds of soda and sulphurous acid are known, viz.:—

1. The neutral or monosulphite	NaO,SO^2
2. The bisulphite	$NaO,2SO^2$

If an excess of sulphurous acid gas be passed through a solution of one part of crystallized carbonate of soda dissolved in two parts of water, the solution, as it cools, deposits crystals of the *bisulphite of soda*, $NaO,2SO^2,9HO$ (Clark). This salt forms four-sided rectangular prisms, which redden vegetable blues, have an acid taste, and smell of sulphurous acid.

If the solution of the bisulphite be saturated with carbonate of soda, the *neutral* or *monosulphite*, commonly called *sulphite of soda*, is obtained. It crystallizes in prisms. $NaO,SO^2,8HO$.

A sulphite of soda has been employed in medicine; but as its efficacy depends on the sulphurous acid which it contains, it is obvious that for medicinal purposes the bisulphite is to be preferred to the neutral sulphite.

Bisulphite of soda has been used as a resolvent, disinfectant, and antiseptic; but its effects have scarcely been examined. When the epidemic cholera raged in Paris, MM. Kurz and Manuel recommended the employment of sulphurous acid fumigations in the narrow streets of the capital (see *ante*, p. 462), and the exhibition of the sulphites of soda and potash to the patients.[1]—The dose of this salt is from ʒss. to ʒj.

A solution of bisulphite of soda has been used as a preservative of bodies for dissection. The solution is prepared by passing sulphurous acid through a concentrated solution of crystallized carbonate of soda, taking care that the liquid is fully saturated with gas, for if it retains any alkaline properties, it promotes rather than retards putrefaction. As much of the solution as the vessels will contain is injected by one of the common carotid arteries; and when all necessary conditions have been observed, it will preserve a subject from putrefaction during a month or six weeks.[2] This antiseptic process has been used with great success in the Parisian anatomical schools. The advantages of this solution are, that while it preserves the body from putrefaction, it does not destroy the scalpels, and does not cause any inconvenience when applied to cuts or abraded surfaces.[3]

Sulphite of soda is sometimes used to prevent the fermentation of vegetable juices. When a few grains of it are put into a bottle along with a fermentible juice, the acid of the latter decomposes the salt, which evolves sulphurous acid. This is endowed with a remarkable power of preventing fermentation, probably by destroying the yeast plant or its seeds.

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[1] Mérat et de Lens, *Dict. Mat. Méd.* t. vi. p. 484.

[2] Hamilton, *Lancet*, Jan. 29, 1848, p. 138.

[3] Mérat, *Dict. de Mat. Méd.* Supplement, ou t. vii. p. 670, 1846.

62. SODÆ SULPHAS.—SULPHATE OF SODA.

Formula NaO,SO^3. *Equivalent Weight* 71.

HISTORY.—Sulphate of soda (also called *natron vitriolatum, Glauber's salt, sal catharticus Glauberi,* or *sal mirabile Glauberi*), was discovered in 1658 by Glauber.

NATURAL HISTORY.—It occurs in both kingdoms of nature.

α. IN THE INORGANISED KINGDOM.—As an efflorescence, the hydrous sulphate of soda is met with in various parts of the world. In the anhydrous state, mixed with a minute portion of carbonate of soda, it constitutes the mineral called *Thenardite.* Sulphate of soda is a constituent of many mineral waters (see *ante*, p. 301).

β. IN THE ORGANISED KINGDOM.—It is found in the ashes of some plants which grow by the sea-shore; as the *Tamarix gallica*. Lastly, it is found in some of the animal fluids; as the blood and urine.

PREPARATION.—Sulphate of soda is a product of several processes, especially of the manufacture of hydrochloric acid.

The *London College* orders of the salt which remains after the distillation of Hydrochloric Acid, lbij.; Boiling Water, Oij; Carbonate of Soda, as much as is necessary. Dissolve the salt in the water, add the marble so long as effervescence takes place, boil the liquid, and when neutral filter it; wash the insoluble matter with boiling water, adding the water to the original liquid; concentrate till a pellicle begins to form, and then let the liquid cool and crystallize.

The *Edinburgh College* orders of the salt which remains, after preparing Pure Muriatic Acid, lbij.; Boiling Water, Oiij.; White Marble, in powder, a sufficiency. Dissolve the Salt in the Water, then gradually add as much Carbonate of Soda as is sufficient to saturate the Acid. Boil down until a pellicle appears, and the solution being strained, set it aside that the crystals may be formed. The liquor being poured off, dry them.

The directions of the *Dublin College* are as follows:—Let the salt which remains after the distillation of Muriatic Acid be dissolved in a sufficient quantity of hot water. Put aside the filtered liquor, that, after due evaporation, crystals may be formed by slow cooling.

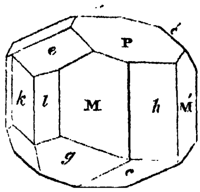
The salt which remains after the distillation of hydrochloric acid is sulphate of soda usually contaminated with some free sulphuric acid, to neutralize which the London College uses carbonate of soda,—the Edinburgh College, marble (carbonate of lime).

In consequence of the enormous consumption of sulphate of soda in the manufacture of carbonate of soda, makers of the latter article are obliged to procure sulphate purposely, by the addition of sulphuric acid to chloride of sodium (see *ante*, p. 526).

PROPERTIES.—It crystallizes in oblique rhombic prisms, which belong to the oblique prismatic system. To the taste this salt is cooling, and bitterish saline. By exposure to the air it effloresces. When heated it undergoes the watery fusion, gives out its water of crystallization, and thereby becomes a white solid, and at a red heat it again becomes liquid. One part of it dissolves in three parts of water at 60°, or one part of water at 212°. It is insoluble in alcohol.

Characteristics.—Its characteristics are those for sulphuric acid and soda before mentioned (see *ante*, pp. 355 and 523). To these may be added its crystalline form. From the bisulphate of soda it is distinguished by its not reddening litmus, and by its less solubility.

FIG. 91.



Prism of Sulphate of Soda.

Crystals of *anhydrous sulphate of soda* (NaO,SO^3) are distinguished by their form being the rhombic octohedron, and by their not losing weight when heated.

The *octohydrated sulphate of soda* is distinguished from the *decahydrated sulphate* (the common sulphate of the shops) by the shape of the crystals, which are quadrangular tables or double four-sided pyramids; by their peculiar hardness, and by the quantity of water which they lose when heated.

Composition.—The ordinary crystals of sulphate of soda have the following composition.—

	Atoms.	*Eq. Wt.*	*Per Cent.*	*Berzelius.*	*Wenzel.*
Soda	1	31	19·25	19·24	19·5
Sulphuric Acid	1	40	24·85	24·76	24·3
Water	10	90	55·90	56·00	55·2
Ordinary Crystals of Sulphate of Soda	1	161	100·00	100·00	99·0

These crystals may, therefore, be denominated the *decahydrate of sulphate of soda,* to distinguish them from the *anhydrous sulphate* as well as the *octohydrate of sulphate of soda* above alluded to.

Purity.—The crystallized sulphate of soda of the shops is usually sufficiently pure for medical purposes. The presence of chlorides in it may be detected by nitrate of silver.

Exposed to the air it falls to powder. Totally dissolved by water; very slightly by alcohol. It does not alter the colour of litmus or turmeric. Nitrate of silver throws down scarcely any thing from a dilute solution; nitrate of barytes more, which is not dissolved by nitric acid. 100 parts of this salt lose 55·5 parts by a strong heat."—*Ph. L.*

Physiological Effects.—It is a mild but efficient cooling laxative or purgative salt, promoting secretion and exhalation from the mucous membrane of the stomach and bowels, without causing inflammation or fever. The antiplastic effects of this salt have already been noticed (see *ante,* pp. 109 and 179), as well as its endosmotic effects (see *ante,* pp. 91 and 92).

Uses.—It is employed as a common purgative, either alone or added to other purgatives. It is applicable in fevers and inflammatory affections, where we want to evacuate the bowels without increasing or causing febrile disorder.

Administration.—The usual dose of it is from ʒvj. to ʒviij. When dried so as to expel the water of crystallization, ʒiijss. act as an efficient purgative.

63. SODII CHLORIDUM.—CHLORIDE OF SODIUM.

Formula $NaCl$. *Equivalent Weight* 58·5.

History.—As this salt is a necessary and indispensable seasoning to our food, it doubtless must have been known to, and employed by the first individuals of our race. The earliest notice of it occurs in the writings of Moses[1] and Homer.[2] It has received various names, such as *common salt* (*sal commune*), *culinary salt* (*sal culinare*), *sea salt* (*sal marinum*), and *muriate* or *hydrochlorate of soda* (*sodæ murias* vel *hydrochloras*).

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[1] *Gen.* xix. 26; *Lev.* ii. 13.

[2] *Iliad,* lib. ix. 214.

Its more correct appellation is *chloride* or *chloruret of sodium* (*sodii chloridum* seu *chloruretum*). These names must not, however, be confounded with "chloride of soda" or "chloruret of soda," or "chloruret of the oxide of sodium," terms which are applied to a bleaching solution of hypochlorite of soda (see *Sodæ Hypochloris*).

NATURAL HISTORY.—It occurs in both kingdoms of nature:

a. IN THE INORGANISED KINGDOM.—An enormous quantity of this salt is contained in the waters of the ocean. At an average calculation, sea water contains 2·5 per cent. of chloride of sodium (see *ante*, p. 292). It is found also in great abundance in mineral waters.[1] It has not hitherto been found in the oldest stratified rocks,[2] but is met with in all the later formations. Thus Mr. Featherstonhaugh[3] states, that salt or brine springs occur in certain parts of the United States,[4] in the *old transition slate rocks*. Salt springs occur in various parts of England, in the *coal measures*.[5] The rock salt of Cheshire, and the brine springs of Worcestershire, occur in the *old red sandstone group*.[6] The salt of Ischel, in the Austrian Alps, belongs to the *oolitic group*,[7] as does also that found in the lias in Switzerland.[8] The immense mass or bed of salt near Cardona, in Spain, and which has been described by Dr. Traill,[9] occurs in the *cretaceous group*.[10] The salt deposit of Wieliczka, near Cracow, belongs to the *supracretaceous group*.[11] Lastly, in the Crimea, salt is said to be daily accumulating in the inland lakes.

β. IN THE ORGANISED KINGDOM.—It is found in plants which grow by the sea side, in the blood and urine of man, &c.

PREPARATION.—The salt consumed in this country is chiefly procured by the evaporation of the water of brine springs. The salt districts are Northwich, Middlewich, and Nantwich, in Cheshire; Shirleywich, in Staffordshire; and Droitwich, in Worcestershire. In Cheshire, the rock salt (called also *fossil salt*, *sal fossilis* or *sal gemmæ*) constitutes two beds, which vary in thickness from 4 to 130 feet, and are separated by a bed of clay, 10 or twelve feet thick; the uppermost bed of salt being 30 or more feet from the surface of the earth. It is for the most part of a reddish colour, but is also met with in transparent, colourless masses. It is called in commerce *Prussia rock*, and is largely exported for purification. Brine springs are met with both above and below the level of the beds of rock salt.

The brine is pumped up into cisterns or reservoirs, from which it is drawn when wanted into large oblong wrought-iron evaporating pans, which are usually worked with four or more fires. If the brine be not completely saturated with chloride of sodium, a little rock salt is added to it. By the evaporation of the water, the salt deposits in crystals. The impurities separate in the form of a scum (which is removed by a skimming-dish), and of a sediment called *pan-scale*, *pan-scratch*, or *pan-bake*. The grains or crystals of salt vary in size according to the degree of heat employed in their preparation. The *small-grained salt* is formed by the strongest heat, and

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[1] Gairdner, *On Mineral Springs*, p. 12.

[2] De la Beche, *Researches in Theoret. Geol.* p. 31.

[3] *Phil. Mag.* N.S. vol. v. p. 139; vol. vi. p. 75; and vol. vii. p. 198.

[4] For an account of the American salt formation, consult J. Van Rensselaer's *Essay on Salt, containing Notices of its Origin, Formation, Geological Position, and principal Localities, embracing a particular Description of the American Salines*, New York, 1823.—This author states that the American salt formation occurs in the old red sandstone.

[5] Bakewell, *Introd. to Geology*, 4th edit. p. 252.

[6] *Trans. Geol. Society*, vol. i. p. 38, and vol. ii. p. 94.

[7] Sedgwick and Murchison, *Phil. Mag.* N.S. vol. viii. p. 102.

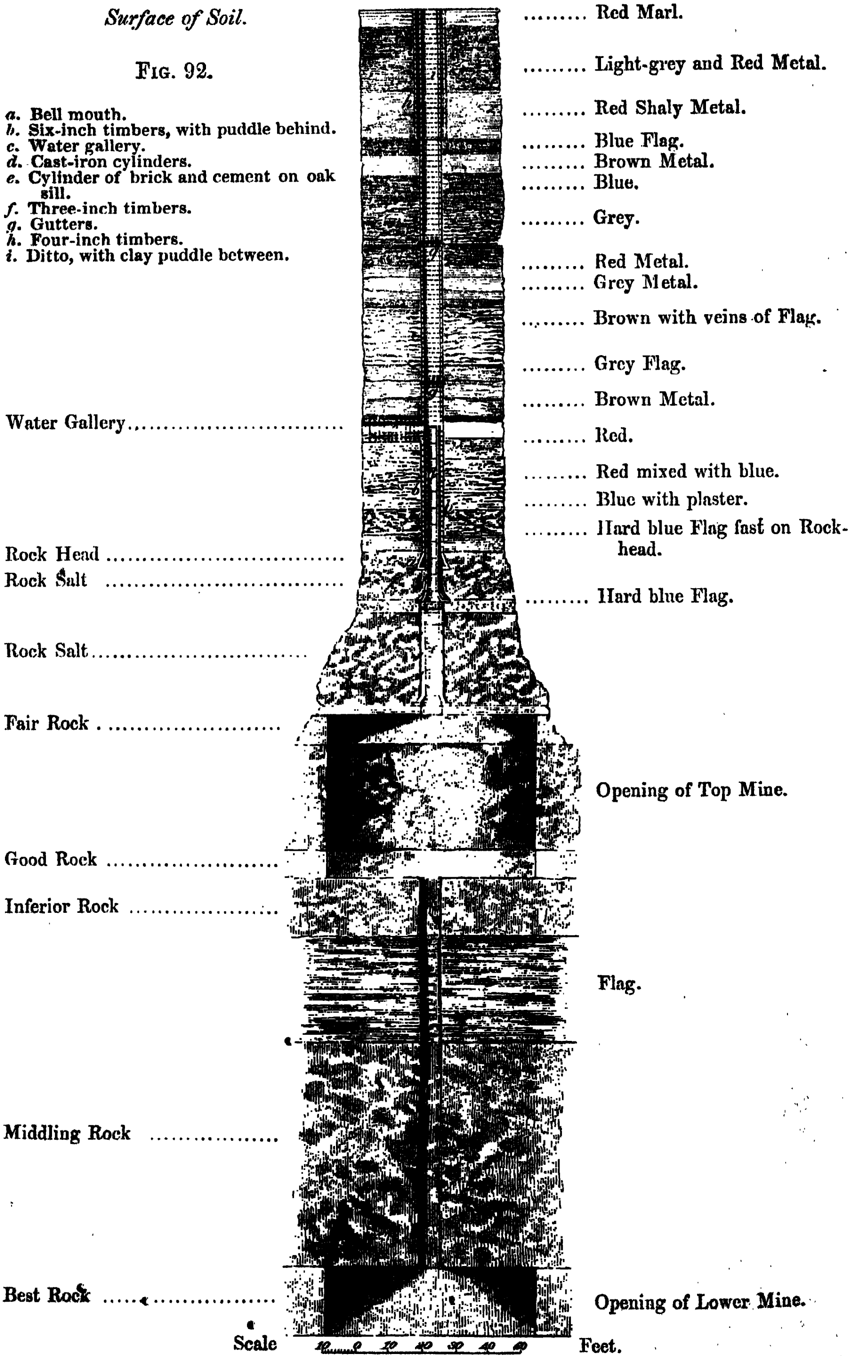
[8] Bakewell, *op. cit.* p. 253.

[9] *Trans. Geol. Society*, vol. iii. p. 404.

[10] De la Beche, *op. cit.* p. 293.

[11] *Ibid.* p. 270.

FIG. 92.

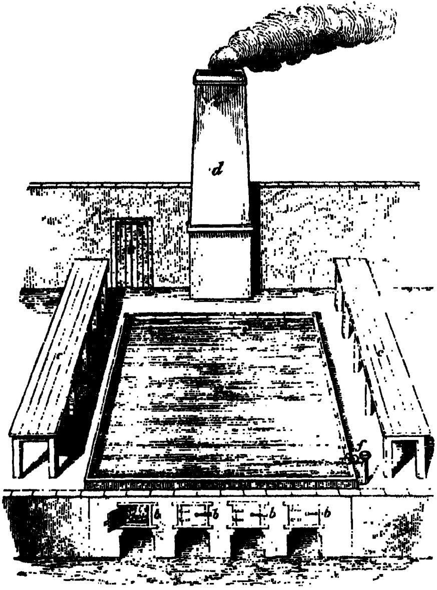


Section of the Wharton Salt Mine, on the River Weaver, Cheshire.

FIG. 93.

a. A flat shallow pan, varying in width and length from 20 feet and upward, and 15 inches deep, made of thick wrought iron.

b. Fire-places, the flues of which go direct to the chimney.



c. Hurdles on which the salt is drawn, to allow it to drain before it is conveyed to the store.

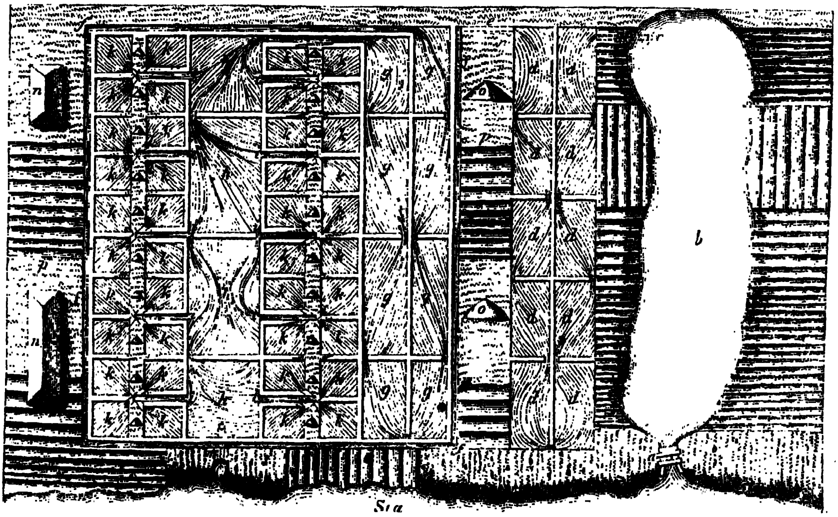
d. Chimney at extremity of pan.

e. Door of the store.

f. Feed-cock supplying brine to the pan.

Common Salt Pan.

FIG. 94.



Salt Marshes.

Sluice by which the sea water is admitted. *b.* Reservoir. *c.* Subterranean channel by which the water passes from *b* into *d.* *d, d.* First series of brine-pits or salt-pans. *e.* Subterranean channel by which the water passes from *d* to *f.* *f.* A long, narrow, circuitous canal. *g, g.* Second series of pans. *h, h.* Third ditto. *i, i.* Canal. *k, k.* Last series of pans. *l, l.* Subterranean channel by which the water passes from *i* to *k.* *m.* Subterranean channel by which the rinsings of the pans escape into the sea. *n, n.* Pyramidal heaps of bay salt. *o, o.* Conical heaps of ditto. *p, p.* Ground of the proprietors of the marshes.

constitutes the *butter, stoved, lump,* or *basket salt* of commerce; while the larger crystals, forming the *bay* and *fishery salts* of commerce, are formed at a lower temperature.[1]

In some places, chloride of sodium is obtained from sea water: but the mode of extraction varies according to circumstances. In France and on the shores of the Mediterranean, it is procured by solar evaporation, and is then called *bay salt.*

The French *salt marshes* (see fig. 94) are shallow basins or pans of clay, excavated along the sea shore. The water is admitted, by a sluice, into a reservoir, where evaporation goes on while mechanical impurities are deposited. It then passes by a subterraneous communication into a series of rectangular pans, and proceeds by a very circuitous route through them to another subterranean gutter, by which it is conveyed into a long, narrow, circuitous canal. From this it passes into a second, and subsequently into a third series of salt pans. During the whole of this time it is undergoing evaporation, and when it arrives at the third series of pans it is so far concentrated that crystallization is soon effected. The salt is known to be on the point of crystallizing when the liquid assumes a reddish tint. It is then withdrawn from the pans, and collected upon the borders, in conical or pyramidal heaps, when it drains and dries. These operations begin in March, and finish in September.[2]

At Lymington,[3] in Hampshire, salt is prepared from the sea water, which is admitted into a reservoir or pond, and from this successively into three series of brine pits or *salt-pans,* where the water is partly evaporated by solar heat. When the liquid has acquired a sufficient density, it is conveyed into rectangular iron pans, where it is evaporated by artificial heat. Eight hours are required to boil each charge to dryness. The salt is then removed into wooden troughs or cisterns, perforated by holes in the bottom, where it is allowed to drain; and is afterwards removed to the warehouse, where it also drains. The drainings from the wooden trough drop on upright stakes (old broom handles, &c.), and on these the salt concretes in the course of ten or twelve days, forming large stalactitic masses called *salt-cats,* each weighing 60 or 80 lbs. The residual liquor (*bittern* or *the bitter liquor*) is received into underground pits, and during the winter season is used in the manufacture of Epsom salt (see *sulphate of magnesia*).

In cold countries, congelation is resorted to as a means of concentrating sea water; for when a weak saline solution is exposed to great cold, it separates into two parts: one almost pure water, which freezes; and the other which remains liquid, and contains the larger proportion of salt. Another method of concentration is by *graduating houses:* these are skeletons of houses, in which the water is pumped up and allowed to fall on heaps of brush-wood, thorns, &c., by which it is divided and agitated with the air, and evaporation promoted. The further concentration is effected by heat.[4]

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[1] For further information on the manufacture of common salt, consult Aikin's *Dictionary of Chemistry,* vol. ii. p. 118; Holland's *Agricultural Survey of Cheshire;* Dr. Henry, *Phil. Trans.* 1810; Mr. Furnival's *Wharton and Marston Patent Salt Refineries,* 1836; Dr. Brownrigg's *Art of Making Common Salt,* 1748; and Dr. Jackson, *Phil. Trans.* No. 53, p. 1060.

[2] For further details, see *Phil. Trans.* No. 51, p. 1025; and Dumas, *Traité de Chimie,* t. ii.

[3] Dr. Henry (*Phil. Trans.* 1810) has described the method of manufacture. In the summer of 1840, I visited the Salterns at Lymington, and can confirm the accuracy of Dr. Henry's statements. I found *Salicornia herbacea* growing abundantly in the salt-pans. The sp. gr. of the liquor in the pans is ascertained by glass bulbs (on the principle of Lovi's beads) placed in a wicker basket, which is immersed in the water by a long handle.

[4] See Knapp's *Chemical Technology.*

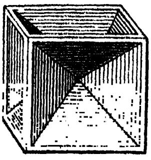
PURIFICATION.—The *Edinburgh College* gives the following directions for the preparation of *pure chloride of sodium* (*sodæ murias purum,* E.)

> "Take any convenient quantity of Muriate of Soda; dissolve it in boiling water; filter the solution, and boil it down over the fire, skimming off the crystals which form; wash the crystals quickly with cold water and dry them."
>
> A solution of this pure salt "is not precipitated by solution of carbonate of ammonia followed by solution of phosphate of soda: a solution of 9 grains in distilled water is not entirely precipitated by a solution of 26 grains of nitrate of silver."

The carbonate of ammonia and phosphate of soda are employed to detect the presence of any magnesian salt.

PROPERTIES.—It crystallizes in colourless cubes, or more rarely in regular octohedrons. In the salt-pans the little cubes are frequently so aggregated as to form hollow, four-sided pyramids: these, I am told, are technically termed *hoppers*. The specific weight of salt is 2·17. The taste is pure saline. When free from all foreign matters, chloride of sodium is permanent in the air; but ordinary salt is slightly deliquescent, owing to the presence of small quantities of chloride of magnesium. When heated, it decrepitates (more especially the coarse-grained or bay salt); at a red heat, fuses; and, at a still higher temperature, volatilizes. Rock salt is transcalent or diathermanous; that is, it transmits radiant heat much more readily than many other transparent bodies, as glass (see *ante*, p. 9). It is soluble in water, and slightly so in alcohol. Hot and even boiling water dissolves very little more salt than cold water. At 60°, it requires about twice and a half its weight of water to dissolve it.

FIG. 95.



Cavernous Cube of Common Salt.

Characteristics.—Its characters as a sodium salt are those for soda, before mentioned (see *ante*, p. 523). As a chloride, it is known by the tests for this class of salts already described (see *ante*, p. 369). In addition to the above characteristics, must be added the cubical shape of the crystals of common salt, and of the absence of odour and of bleaching property.

COMPOSITION.—Pure chloride of sodium has the following composition:—

	Atoms.	*Eq. Wt.*	*Per Cent.*	*Ure.*	*Longchamps.*
Sodium	1	23	39·3	39·98	39·767
Chlorine	1	35·5	60·7	60·02	60·233
Chloride of Sodium	1	58·5	100·0	100·00	100·000

The crystals contain no water in chemical combination with them, but a little is frequently mechanically lodged between their plates.

IMPURITIES.—The commercial salt of this country is sufficiently pure for all dietetical and therapeutical purposes; and its low price is a sufficient guarantee against adulteration. In France, however, serious accidents have happened in consequence of the use of sophisticated salt.[1]

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[1] Christison's *Treatise on Poisons*, 3d edit. p. 604; and Devergie, *Méd. Lég.* t. ii. p. 876.

COMPOSITION OF VARIOUS KINDS OF SALT (HENRY).

Kind of Salt.		1000 *Parts by Weight consist of*								
		Pure Muriate of Soda.	Muriate of Lime.	Muriate of Magnesia.	Total Earthy Muriates.	Sulphate of Lime.	Sulphate of Magnesia.	Total Sulphates.	Insoluble Matter.	Total Impurity.
Foreign Bay Salt	St. Ube's............	960	trace	3	3	23½	4½	28	9	40
	St. Martin's	959½	do.	3½	3½	19	6	25	12	40½
	Oleron..............	964¼	do.	2	2	19½	4¼	23¾	10	35¾
British Salt from Sea Water	Scotch (common)....	935½	—	28	28	15	17½	32½	4	64½
	Scotch (Sunday)	971	—	11½	11½	12	4½	16½	1	29
	Lymington (common)	937	—	11	11	15	35	50	2	63
	Ditto (cat)	988	—	5	5	1	5	6	1	12
Cheshire Salt....	Crushed rock........	983¼	0·1/16	0·3/16	0·¼	6½	—	6½	10	16¾
	Fishery	986	0·¼	0 ¾	1	11¼	—	11¼	1	13¼
	Common............	983½	0·¼	0·¾	1	14½	—	14½	1	16½
	Stoved	982½	0·¼	0·¾	1	15½	—	15½	1	17½

PHYSIOLOGICAL EFFECTS. α. *On Vegetables.*—In minute quantity, chloride of sodium is injurious to very few, if any, plants, and to some it appears to be beneficial. Used moderately, it is a most excellent manure to certain soils. In large quantities it is injurious, though unequally so, to all plants.[1]

β. *On Animals.*—To marine animals, common salt is a necessary constituent of their drink. It is relished by most land animals. "The eagerness with which many quadrupeds and birds press towards salt springs and lakes, situated in land districts, for the purpose of tasting their contents, indicates," says Dr. Fleming,[2] "a constitutional fondness for salt." In the *Ruminantia*, the salutary effects of salt are especially observed. "They contribute powerfully," observes Moiroud,[3] "to prevent, in these animals, the influence of rainy seasons and wet pasturage, as well as damaged fodder. Given to animals intended for fattening, it gives more consistence to the fat and more taste to the meat." It appears to be offensive and injurious to many of the lower animals: hence, when rubbed on meat, it prevents the attack of insects; and when applied to the skin of leeches, causes vomiting.

γ. *On Man.*—Chloride of sodium serves some important and essential uses in the animal economy. It is employed, on account of its agreeable taste, by the people of all nations, from the most refined to the most barbarous; but the quantity taken varies with different individuals.[4] It is an invariable constituent of the healthy blood. Dr. Stevens[5] has shown that, in certain states of disease (as cholera), there is a deficiency of the saline matter in the blood, and in those cases the blood has a very dark or black appearance. Some of the properties of the sanguineous fluid, such as its fluidity, its stimulating qualities, and its power of self-preservation, are probably more or less connected with its saline constituents. The chloride of sodium found in some of the secretions, as the bile and tears, doubtless serves some important purposes.

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[1] Davy, *Agricul. Chem.*; and De Candolle, *Phys. Vég.* pp. 1262 and 1343.

[2] *Philosophy of Zoology*, vol. i. p. 316.

[3] *Pharmac. Vétérin.* p. 410.

[4] For an account of the dietetical effects and uses of salt, see the author's *Treatise on Food and Diet.*

[5] *On the Blood.*

It is said that persons who take little or no salt with their food are very subject to intestinal worms. Lord Somerville, in his address to the Board of Agriculture, states that the ancient laws of Holland "ordained men to be kept on bread alone, *unmixed with salt,* as the severest punishment that could be inflicted upon them in their moist climate: the effect was horrible;—these wretched criminals are said to have been *devoured by worms* engendered in their own stomachs." Mr. Marshall[1] tells us of a lady who had a natural aversion to salt: she was most dreadfully affected with worms during the whole of her life.

Considered in a therapeutical point of view, it is an irritant in its local operation. Thus, applied to the skin and the mucous membranes, it causes redness. Taken into the stomach in large quantity (as in the dose of a table-spoonful or more), it excites vomiting; and, when thrown into the large intestines, produces purging. In moderate quantities it promotes the appetite and assists digestion and assimilation. If used too freely, it occasions thirst. Dr. Garrod ascribes the scorbutic effects of the salt meat used by sailors to its deficiency in potash, which, by the long-continued action of the common salt, is abstracted by endosmotic action; and he states that he found less potash in salt beef than in fresh beef (see *ante,* p. 464). In large doses it operates as an irritant poison. A man swallowed a pound of it in a pint of ale, and died within twenty-four hours, with all the symptoms of irritant poisoning. His stomach and intestines were found excessively inflamed.[2]

In some diseases, the moderate use of salt produces the effects of a tonic. It acts as a stimulant to the mucous membranes, the absorbent vessels, and glands. In its endosmotic action on the tissues and on the blood-corpuscles, common salt agrees with other saline substances before mentioned (see *ante,* pp. 91, 92, and 179). Its chemical influence on the blood is probably analogous to that of many other salts (see *ante,* pp. 108, 109, and 179).

Properly diluted, and injected into the veins in cholera, it acts as a powerful stimulant and restorative; the pulse, which was before imperceptible, usually becomes almost immediately restored, and, in some cases, reaction and recovery follow. Dr. Macleod injected a solution of common salt into the jugular vein of a rabbit which had been asphyxiated, but without restoring or producing resuscitation.[3]

USES.—The following are some of the most important therapeutical uses of chloride of sodium:—

As a *vomit,* it has been recommended in malignant cholera in preference to other emetics.[4] In narcotic poisoning, in the absence of the stomach-pump and the ordinary emetic substances, it may also be employed. The dose of it is one or two table-spoonfuls in a tumblerful of water. A tea-spoonful of flour of mustard assists its action.

As a *purgative* it is seldom employed, except in the form of enema. One or two table-spoonfuls of common salt, dissolved in a pint of gruel, form a very useful clyster for promoting evacuations from the bowels.

It has been used in some diseases with the view of *restoring the saline qualities of the blood* (see *ante,* pp. 181 and 182).

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[1] *Med. an Phys Journal,* vol. xxxix.

[2] Christison, *Treatise on Poisons.*

[3] *Lond. Med. Gaz.* vol. ix. p. 358.

[4] Searle, *Lond. Med. Gaz.* vol. viii. p. 538; Sir D. Barry, *ibid.* vol. ix. pp. 321 and 407; Brailoff and Isenbeck, *ibid.* p. 490*.

Common salt has been employed as an *anthelmintic* (see *ante*, p. 231). For this purpose it is exhibited in large doses by the mouth; or, when the worms are lodged in the rectum, a strong solution is administered in the form of enema.

When leeches have crept into the rectum, or have been accidentally swallowed, a solution of salt should be immediately used.

As a *chemical antidote*, chloride of sodium may be administered in poisoning by nitrate of silver.

As an *alterative and tonic*, it is useful in scrofula, and glandular diseases.

As an *astringent* in hemorrhages, dysentery, and diarrhœa, it has been administered in combination with lime juice or lemon juice.[1]

It is frequently used as a *dentifrice* (see *ante*, p. 155).

As an *external application*, salt has been used for various purposes. Thus a saturated solution, applied with friction, is employed as a counter-irritant and discutient in glandular enlargements and chronic diseases of the joint: as a stimulant, it is rubbed on the chest in fainting and asphyxia. A solution of salt is employed as a substitute for sea-water; for baths (cold and warm), affusion, the douche, &c. (See *balneum maris factitium*, p. 293.)

ADMINISTRATION.—As a tonic and alterative, the dose is from ten grains to a drachm. As an emetic, from two to three table-spoonfuls in five or six ounces of warm water. As a cathartic, from half an ounce to an ounce.

ENEMA COMMUNE; *Common Clyster*.—Chloride of Sodium, ℥j.; Warm Gruel (or Barley-Water), ℥xij. Mix.—To this some persons add one or two ounces of oil (olive, castor, or linseed oil).

64. SODÆ HYPOCHLORIS.—HYPOCHLORITE OF SODA.

Formula NaO,ClO. *Equivalent Weight* 74·5.

HISTORY.—Hitherto this substance has been obtained only in either mixture or combination with chloride of sodium; and in this state it is usually called *chloride of soda*, *chloruret of the oxide of sodium*, or *oxymuriate of soda*,—names which must not be confounded with "chloride of sodium," "chloruret of sodium," and "muriate of soda,"—terms which are applied to common salt.

The disinfecting power of a solution of chloride of soda was discovered by Labarraque about 1820.[2]

PREPARATION.—1. Solid or dry chloride of soda (*sodæ chloridum siccum*; *natrum oxymuriaticum siccum*) may be prepared in the same way as chloride of lime (hereafter to be described), but substituting carbonate of soda, which has effloresced in the air, and fallen to powder, for the hydrate of lime. The product is a white powder, having an odour of hypochlorous acid, and composed of chloride of soda (*i. e.* hypochlorite of soda and chloride of sodium) and bicarbonate of soda. $4(NaO,CO^2)+2Cl=2(NaO,2CO^2)+NaO,ClO+NaCl$. By solution in eight parts of water, it yields the *liqueur de Labarraque*.[3]

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[1] *Memoir of the late Dr. Wright*, p. 322.

[2] Alcock, *Essay on the Use of the Chlorurets*, p. vi. Lond. 1827.

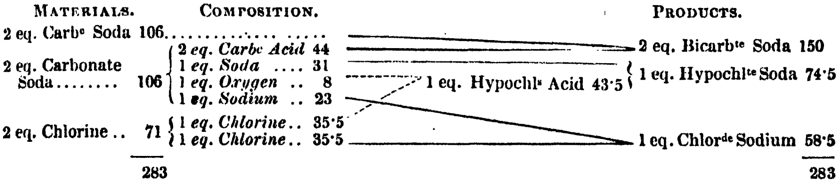
[3] Duflos, *Chemisches Apothekerbuch*, Bd. 1, S. 431, 3tte Ausg. 1847.

2. A solution of chloride of soda (*liquor sodæ chlorinatæ*, Ph. Lond.; *hypochloricus sodicus aquâ solutus*, Fr. Codex), commonly called *liqueur de Labarraque*, or *Labarraque's soda disinfecting fluid*, may be prepared in the way above described, or by either of the two following methods:—

a. In the London Pharmacopœia it is directed to be prepared as follows:—

Take of Carbonate of Soda, lbj.; Distilled Water, f℥xlviij.; Chloride of Sodium, ℥iv.; Binoxide of Manganese, ℥iij.; Sulphuric Acid, ℥iv. Dissolve the carbonate of soda in two pints of water; then put the chloride of sodium and binoxide of manganese, rubbed to powder, into a retort; and add to them the sulphuric acid, previously mixed with three fluidounces of the water, and cooled. Heat (the mixture), and pass the chlorine first through five fluidounces of the water, and afterwards into the solution of the carbonate of soda above directed.

When the chlorine comes in contact with the solution of carbonate of soda, there are formed chloride of soda (hypochlorite of soda and chloride of sodium) and bicarbonate of soda, as above explained.



The essential and characteristic properties of this solution depend on the hypochlorite of soda.

β. In the French Codex, this solution is directed to be prepared as follows:—

Diffuse one part of dry chloride of lime through 30 parts of water; then add two parts of crystallized carbonate of soda, previously dissolved in 15 parts of water. Filter the mixture.

In this process double decomposition takes place; hypochlorite of soda and chloride of sodium are formed in solution, while carbonate of lime is precipitated. $(CaCl + CaO,ClO) + 2(NaO,CO^2) = NaO,ClO + NaCl + 2(CaO,CO^2)$.

This process is more easy of execution than the preceding one. By using the proportions here directed, the solution is weaker than that prepared by the process of the London Pharmacopœia.

PROPERTIES.—The solution of hypochlorite of soda (*liquor sodæ chlorinatæ*, L.) has a yellowish colour, an astringent taste, and an odour of hypochlorous acid. It destroys the colour of vegetable substances; as litmus, turmeric, and sulphate of indigo. Previous to bleaching them, it reacts as an alkali on turmeric paper and infusion of red cabbage. By evaporation, crystals are obtained, which, by resolution in water, reproduce the disinfecting liquid. By exposure to the air, the solution undergoes decomposition, and crystals of carbonate of soda are formed.

Characteristics.—The following are the essential characters of this solution:—

It decolorizes sulphate of indigo. It has the odour of hypochlorous acid. On the addition of hydrochloric acid, chlorine and carbonic acid are evolved, and chloride of sodium is left in solution $(NaO,ClO + NaCl + 2(NaO,2CO^2) + 4HCl = 4NaCl + 2Cl + 4CO^2 + 4HO)$. A solution of nitrate of silver throws down a white precipitate (*chloride of silver*), soluble in ammonia, but insoluble in nitric acid. Lime water causes a white precipitate (*carbonate of lime*). Oxalate of ammonia occasions no precipitate, showing the absence of lime. Bichloride of platinum produces no yellow precipitate, proving the absence of potash and ammonia. That the base of the solution is soda may be shown in two ways: evaporated to dryness, we obtain a residuum, which renders the outer cone of the flame of a candle, or the flame of a spirit lamp, yellow; saturated with hydrochloric acid, and evaporated to dryness, common salt is procured.

Composition.—Some chemists regard this liquid as an aqueous solution of chloride of soda and bicarbonate of soda. But its odour is that of hypochlorous acid; and the view usually taken of it is, that it is an aqueous solution of the *hypochlorite of soda, chloride of sodium,* and *bicarbonate of soda.*

Prepared according to the London Pharmacopœia, its composition will be nearly as follows:—

	Atoms.	*Eq. Wt.*	*Per Cent.*
Hypochlorite of Soda	1	74·5	3·11
Chloride of Sodium	1	58·5	2·44
Bicarbonate of Soda	2	150·0	6·26
Water			88·19
Liquor Sodæ Chlorinatæ, *Ph. Lond.*			100·00

Impurity.—A solution of chloride of soda should not yield a precipitate on the addition of a solution of sulphate of magnesia. If a precipitate be obtained, it indicates the presence of the monocarbonate of soda, and the consequent imperfect saturation of the liquid with chlorine.

Physiological Effects. α. *On Animals.*—A solution of the chloride of soda acts more or less powerfully as a local irritant, according to the degree of its concentration. From the experiments of Segalas,[1] it appears that, besides the irritant operation, and its direct and sympathetic action on the organic solids, it exercises an evident influence over the blood, and, in consequence, over the whole economy, by means of absorption. In an experiment referred to by Dr. Christison,[2] two ounces of Labarraque's solution, introduced into the peritoneum of a dog, excited palpitation, oppressed breathing, constant restlessness, and death in ten minutes.

β. *On Man.*—I am unacquainted with any experiments made to determine the physiological effects of chloride of soda on man. That it would, in *large doses,* act as a powerful local irritant, and, if swallowed, give rise to symptoms of gastro-enteritis, cannot, I think, be doubted. Mérat and De Lens[3] state that the immediate consequence of, and predominating symptom produced by, a glassful of *Eau de Javelle* (a solution of chloride of potash) was general rigidity, which gave way to demulcent drinks. This observation agrees with one made by Segalas[4] in his experiments on dogs—namely, that chloride of soda caused tetanic spasms. It is probable, therefore, that the chlorides of the alkalies exercise a specific influence over the nervous system.

Chloride of soda, in *moderate* or *small doses,* has been denominated stimulant, tonic, astringent, antiseptic, and febrifuge. But these terms give no real explanation of the nature of those organic changes which it gives rise to, and from which its therapeutical value is derived. In fever, I have seen dampness of the skin follow its use. Increased secretion of urine is a common effect of it. In fevers it improves the qualities of the evacuations. Under the continued employment of it, glandular enlargements and chronic mucous discharges have disappeared: hence it has been denominated alterative and resolvent. All these effects depend probably on the alteration which it produces in the condition of the blood. We must not overlook the important fact, that the solution of chloride of soda used in medicine contains bicarbonate of soda, to which perhaps in many cases its beneficial effects are, in part at least, to be referred.

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[1] *Journ. de Chim. Méd.* t. i. p. 271.

[2] *Treatise on Poisons,* 3d edit. p. 221.

[3] *Dict. Mat. Méd.* t. ii. p. 257.

[4] Christison, *op. cit.* p. 221.

USES.—The solution of chloride of soda is employed as a *disinfectant*, *antiseptic*, and, in cases of poisoning by the hydrosulphurets, and hydrosulphuric and hydrocyanic acids, as an *antidote*. But for most of these purposes the chloride of lime is employed instead of chloride of soda; since its properties are analogous, and, being manufactured on a very extensive scale for the use of bleachers, it can be obtained more conveniently and cheaply. On this account, therefore, and to avoid repetition, I must refer to the article *hypochlorite of lime* for information respecting the above uses of chloride of soda. I would remark, however, that in several cases where I have carefully tried and compared the two chlorides, I give the decided preference to the chloride of soda. As an antiseptic, Labarraque also preferred the latter preparation, on the ground that by the process of disinfection it becomes chloride of sodium, which is not a deliquescent salt; whereas the chloride of calcium generated by chloride of lime, attracts water from the atmosphere, and thereby furnishes one of the conditions (viz. moisture) necessary to the putrefactive process. Hence, in his opinion, while chloride of lime will serve equally well for mere disinfection, chloride of soda is preferable where we wish at the same time to prevent a renewal of putrefaction.

Chloride of soda is employed internally in all diseases commonly termed *putrid* or *malignant*—as typhus fever, scarlatina maligna, &c. It is indicated where there are great prostration of strength, fetid evacuations, and a dry and furred tongue. In such cases I have seen it of essential service, improving the quality of the secretions, producing a moist state of the skin, preventing collapse, and altogether acting most beneficially. It may be administered both by the mouth and the rectum.

There are many other diseases in which it is stated to have been administered internally with apparent success; for example, in intermittents, as a substitute for the disulphate of quinia, it has been recommended by Lalesque and Gouzée;[1] in secondary syphilis, it has been used by Dr. Scott[2] and by Cazenove;[3] in chronic skin diseases, and as a substitute for chlorine in bilious disorders, by Dr. Darling;[4] in scrofula, by Godier;[5] and in plague, by

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[1] *Brit. and For. Med. Rev.* April, 1838.
[2] *Lond. Med. Rep.* N. S. vol. ii. 1836, p. 139.
[3] *Jour. de Chim. Méd.* t. iv. p. 140.
[4] *Lond. Med. Rep.* N. S. vol. ii.
[5] *Journ. Gén. de Méd.* 1829.

Neljoubin.[1] In some of these cases (as in syphilis and scrofula) the benefit obtained may have resulted from the bicarbonate of soda contained in solution.

As a *local* remedy, it is employed in diseases attended with fetid discharges, not merely as a disinfectant and antiseptic—that is, as a chemical agent destroying fetor, and preventing the putrefaction of dead matters (as gangrenous parts, the discharges from wounds and ulcers, &c.), though in these respects it is most valuable—but as a means of stopping or relieving morbid action by changing the action of the living tissues. It frequently puts a stop to the further progress of gangrene; promotes the separation of the dead from the living parts; improves the quality of the secretions; and, at the same time, diminishes their quantity when this is excessive. It is applied to ulcers of various kinds (common, phagedenic, cancerous, syphilitic, and scrofulous) when attended with foul discharges or a disposition to slough. It is of great service in some affections of the mucous surfaces. Thus it is used as a gargle to check ptyalism and affections of the mouth, whether arising from mercury or other causes. In scarlatina maligna, we apply it to check ulceration and sloughing of the throat. In coryza and ozæna, it has been injected into the nostrils with considerable benefit. In fetid and excessive discharges from the vagina and neck of the uterus or bladder, it is employed as an injection with at least temporary relief. It has also been applied in some skin diseases, as tinea capitis, eczema, scabies, prurigo pudendi muliebris, &c. The above are only a few of the cases in which chloride of soda has been used with most marked benefit. In conclusion, I may add that there are few, if any, remedies, the uses of which, as local agents, are so valuable and extensive as the chlorides of soda and lime.

Administration.—The *liquor sodæ chlorinatæ* (Ph. L.) may be administered internally in doses of twenty drops or more, diluted with some mild aqueous liquid.

1. **GARGARISMA SODÆ CHLORINATÆ**; *Gargle of Chloride of Soda.* (Solution of Chlorinated Soda, fʒvj.; Water, f℥xjss. Mix.)—Useful in ulceration and sloughing of the mouth and throat.

2. **LOTIO SODÆ CHLORINATÆ**; *Lotion of Chloride of Soda.* (Solution of Chlorinated Soda, f℥j.; Water, f℥x. to ℥xv. Mix.)—Useful as a wash for foul and sloughing ulcers. In some cases I have seen a lotion composed of equal parts of the solution of chloride of soda and water employed; but in general the strength is that given above.

3. **INJECTIO SODÆ CHLORINATÆ**; *Injection of Chloride of Soda.* (Solution of Chlorinated Soda, f℥j.; Water, f℥xvj.)—Employed as an injection into the vagina in fetid discharges from malignant and other diseases.

4. **CATAPLASMA SODÆ CHLORINATÆ**; *Poultice of Chloride of Soda.*—Linseed-meal made into a poultice with equal parts of solution of chlorinated soda and water. Applied to foul and sloughing ulcers.

Antidotes.—See *Calcis hypochloris.*

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[1] Richter, *Ausf. Arzneim.* Suppl.-Bd. p. 539.

63. SODÆ NITRAS.—NITRATE OF SODA.

Formula NaO,NO^5. *Equivalent Weight* 85.

HISTORY.—Duhamel,[1] probably, was the discoverer of this salt, in 1736. It was first analyzed by Margraff[2] in 1761. It has been termed *cubic*, *quadrangular*, or *rhomboidal nitre* (*nitrum cubicum, quadrangulare* vel *rhomboidale*), or *Chili saltpetre*.

NATURAL HISTORY.—It is peculiar to the mineral kingdom.

Native nitrate of soda is found in South Peru. It exists in large beds, a few feet below the saline soil, or forming that soil in various places, from Arica on the north and west, to the course of the river Loa on the south. There is a large deposit in the district of Tarapaca. It is found in distinct strata, a thin layer of brown loam separating the parts.[3]

Native nitrate of soda, in fractured masses, has a granular structure, arising from the aggregation of irregular rhombic crystals, varying from fine grained to coarse grained. Colour, from snow white to reddish brown or grey. Odour peculiar; and, when warmed, resembling chloride of iodine dissolved in water. Its average composition is *nitrate of soda*, 64·98; *sulphate of soda*, 3·00; *chloride of sodium*, 28·69; *iodic salts*, 0·63; *shells and marl*, 2·60 = 99·90.[4]

EXTRACTION.—"The richest masses of the native salt are blasted or broken, and divided into small portions; with these copper kettles are in part filled, and water, or the mother water of former operations, is added, and heat applied, until a boiling and saturated solution is obtained. The solution is transferred to wooden coolers, where the nitrate of soda crystallizes. The undissolved salt remaining in the kettles is thrown aside, fresh salt being used each time, although not one half of the nitrate of soda is dissolved. The coolers are emptied after the crystals of nitrate have ceased to form: it is dried, packed in bags, and sent to the coast on mules."

COMMERCE.—In 1839, duty (6d. per cwt.) was paid on 107,922 cwts. In 1840, on 130,211 cwts.[5]

CRUDE NITRATE OF SODA.—The rough or crude Chili saltpetre (*sodæ nitras crudus; nitrum cubicum*) imported into Europe consists of crystals having a dirty or brownish appearance. Its composition is said to be as follows:—

	Hoffstetter.	*Lecanu.*	*Wittstein.*
Nitrate of soda	94·29	96·70	99·63
" potash	0·43	—	—
" magnesia	0·86	—	—
" lime	—	trace	trace
Chloride of sodium	1·99	1·30	0·37
Sulphate of potash	0·24	trace	—
Water	1·99	2·00	—
Insoluble matter	0·20	—	—
	100·00	100·00	100·00

Also small quantities of iodide of sodium and iodate of soda (Lembert).

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[1] *Mémoires de l'Académie Royale des Sciences*, 1736, p. 215.

[2] *Opusc.* ii. 331.

[3] Hayes, in Silliman's *Journal*; also in *The Chemist*, for February, 1841, No. xiv. p. 43. Rivero, in the *Edinb. Phil. Journ.* vol. vii. p. 184, Edinb. 1822.

[4] *Ibid.*

[5] *Trade List*, Jan. 5, 1841.

The small quantities of the iodic salts found in Chili saltpetre explains the fact before noticed (see *ante*, p. 413), that commercial nitric acid (which is frequently obtained from this salt) sometimes contains iodine.

After its arrival in this country, the crude Chili saltpetre is refined by solution and re-crystallization. The salt is then termed *refined nitrate of soda* (*sodæ nitras depuratus*).

PROPERTIES.—It usually crystallizes in obtuse rhombohedral crystals, which belong to the rhombohedral system. Its taste is somewhat bitter. In moist air it is slightly deliquescent. It is soluble in about two parts of cold water, and in less than its own weight at 212°. It fuses by heat.

Characteristics.—As a nitrate, it is known by the characters of this class of salts already stated (see *ante*, p. 412). The nature of its base is recognised by the tests for soda already described (see *ante*, p. 523). The yellow colour which it communicates to flame, as well as the shape of its crystals, readily distinguish it from nitrate of potash.

COMPOSITION.—Crystallized nitrate of soda is anhydrous.

	Atoms.	*Eq. Wt.*	*Per Cent.*	*Longchamp.*	*Wenzel.*
Soda	1	31	36·47	36·75	37·5
Nitric Acid	1	54	63·53	63·25	62·5
Crystallized Nitrate of Soda	1	85	100·00	100·00	100·0

IMPURITIES.—See *Potassæ Nitras*, p. 510.

PHYSIOLOGICAL EFFECTS.—Its effects are similar to those of nitrate of potash. According to Wolfers,[1] from two to four drachms of it may be taken daily without any hurtful effect. Velsen states that it does not so readily disturb digestion as nitrate of potash.

USES.—It is not employed in medicine in this country. As a substitute for nitrate of potash, it is used in the manufacture of nitric and sulphuric acids. It is employed by firework-makers; and also as a manure, especially for wheat.[2] On account of its deliquescence, it is unfit for the manufacture of gunpowder.

66. SODÆ ACETAS.—ACETATE OF SODA.

Formula $NaO,C^4H^3O^3$; or $NaO,\bar{A}$. *Equivalent Weight* 82.

HISTORY.—This salt was first described by Baron, in 1747;[3] but, according to Dulk,[4] its real discoverer was F. Meyer, in 1677. It was formerly called *terra foliata tartari crystallisata*, or *terra foliata mineralis*.

PREPARATION.—Acetate of soda is usually prepared by makers of pyroligneous acid, and the mode of manufacturing it will be noticed hereafter (see *Acidum Aceticum*). It is procured by saturating acetic acid by carbonate of soda, and evaporating the solution so that crystals may form.

The *Dublin College* orders it to be prepared by saturating Carbonate of Soda with Distilled Vinegar. The filtered liquor is to be evaporated until it has attained the sp. gr.

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[1] Richter, *Ausführ. Arzneim.* Bd. iv. S. 251.

[2] *Journal of the Royal Agricultural Society of England*, for 1840 and 1841.

[3] Thomson's *Chem. of Inorg. Bod.* vol. ii. p. 464.

[4] *Die Preuss. Pharm. übers u. erläut.*

of 1·276. By cooling, crystals are formed, which are to be cautiously dried and kept in a close vessel.

PROPERTIES.—This salt crystallizes in oblique rhombic prisms. Geiger[1] says that a saturated solution of this salt does not readily crystallize when cooled in a tall glass vessel unless some pointed or angular body be introduced. Its taste is cooling, saline, and bitterish. Exposed to the air, at ordinary temperatures, the crystals undergo little change; but in dry and warm air they effloresce and become anhydrous. When heated, they first undergo the watery fusion, then give out their water of crystallization, and afterwards enter into igneous fusion. At a red heat they are decomposed, and yield, as a residue, a mixture of charcoal and carbonate of soda. They are soluble in about three parts of cold water, and are slightly soluble in alcohol.

Characteristics.—As an acetate, this salt is recognized by the evolution of the vapour of acetic acid when oil of vitriol is poured over it. That it is a soda salt is shown by the characters already described for this base (see *ante*, p. 523).

COMPOSITION.—The following is the composition of this salt:—

	Atoms.	*Eq. Wt.*	*Per Cent.*	*Berzelius.*
Soda	1	31	22·8	22·94
Acetic Acid	1	51	37·5	36·95
Water	6	54	39·7	40·11
Crystallized Acetate of Soda	1	136	100·0	100·00

PURITY.—It should be white and perfectly neutral to test-papers (litmus and turmeric). The presence of sulphuric acid may be recognized by chloride of barium, which occasions with this acid a white precipitate insoluble in nitric acid. If nitrate of silver cause a white precipitate insoluble in both water and nitric acid, but soluble in ammonia, the presence of a chloride is to be inferred. Potash may be recognized by the before-mentioned tests for this base (see *ante*, p. 463), as well as by the deliquescence of the suspected acetate.

PHYSIOLOGICAL EFFECTS.—Acetate of soda operates on the body like acetate of potash (see *ante*, p. 516), but is probably somewhat milder in its action.

USES.—It is rarely employed for medicinal purposes. It may, however, be used as a substitute for acetate of potash, over which it has the advantage of not being deliquescent.

In pharmacy and the arts it is largely employed in the manufacture of acetic acid, and on this account has been introduced into the Pharmacopœia as the officinal source of this acid.

ADMINISTRATION.—The dose of it, as a diuretic, is from ℈j. to ʒij.

67. Sodæ Tartras.—Neutral or Bibasic Tartrate of Soda.

Formula $2NaO,C^8H^4O^{10}$; or $2NaO,\bar{T}$. *Equivalent Weight* 194.

This salt is obtained by saturating a solution of tartaric acid with either the carbonate or bicarbonate of soda. It is formed, therefore, in the preparation of the effervescing draught made with the above ingredient, or when *soda-powders* (see *ante*, p. 535) are dissolved in water. By evaporation the solution yields acicular crystals of tartrate of soda containing four atoms of water of crystallization, $2NaO,\bar{T},4HO$. They are soluble in their own weight of water; but are insoluble in alcohol. In its medicinal properties, tartrate of soda resembles the tartrate of potash (see *ante*, p. 517). It is a gentle aperient. If it be given so as to become absorbed (see *ante*, pp. 92 and 180), it operates as a diuretic, and renders the urine alkaline (see *ante*, p. 180). It may be used, therefore, in lithic acid deposits, but is objectionable when there are phosphatic deposits in the urine (see *ante*, p. 534),—Dose, as a purgative, ʒij. to ʒiv. or more. As a diuretic or lithic (see *ante*, p. 256), it must be given in smaller doses, and largely diluted with water, so as to ensure its absorption.—By adding to an aqueous solution of 150 grains of crystallized tartaric acid, either 168 grains of bicarbonate of soda or 286 grains of crystallized neutral carbonate, we obtain, in solution, tartrate of soda equal to 232 grains (or nearly ʒiv.) of the crystallized salt.

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[1] *Handb. d. Phar.* 1 Bd. 150, 3 Aufl.

68. POTASSÆ ET SODÆ TARTRAS.—TARTRATE OF POTASH AND SODA.

HISTORY.—This salt was discovered by Seignette, an apothecary at Rochelle, in 1672; and hence it is frequently termed *Seignette's salt*, or *sel de Seignette*.[1] Its composition was discovered by Boulduc and Geoffroy in 1731. He called it *alkaline salt*, *sal polychrest*, and *Rochelle salt* (*sal Rupellensis* vel *Rochellense*). To distinguish it from the sal polychrest (sulphate of potash) of other writers, it is sometimes denominated *sal polychrestum Seignetti*. It is often called *tartarised soda* (*soda tartarizata* seu *natron tartarizatum*). In the London Pharmacopœia it is denominated *sodæ potassio-tartras*; but the term *potassæ sodio-tartras* would be probably more correct. The Edinburgh and Dublin Colleges call it *potassæ et sodæ tartras*.

PREPARATION.—All the British Colleges give directions for its preparation:

The *London College* orders of Bitartrate of Potash, powdered, ℥xvj.; Carbonate of Soda, ℥xij.; Boiling Water, Oiv. Dissolve the carbonate of soda in the boiling water, and add gradually the bitartrate of potash. Strain the liquor; then apply a gentle heat until a pellicle floats, and set it aside that crystals may be formed. The liquor being poured off, dry them. Evaporate the liquor again that it may yield crystals.

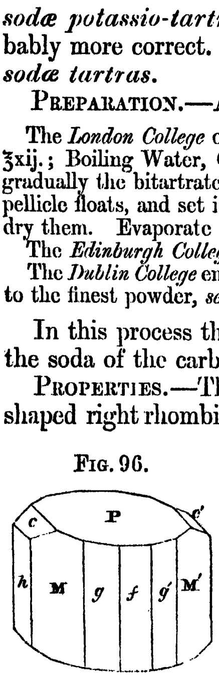
The *Edinburgh College* orders the same quantities.

The *Dublin College* employs Carbonate of Soda, *five parts*; Bitartrate of Potash, reduced to the finest powder, *seven parts*; Hot Water, *fifty parts*.

In this process the excess of acid in the bitartrate of potash is saturated by the soda of the carbonate; while the carbonic acid of the latter is disengaged.

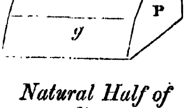
PROPERTIES.—This salt is met with in large, transparent, and regularly-shaped right rhombic prisms; but, curiously enough, the crystals are frequently produced in halves (as in fig. 97). Their taste is mildly saline and bitter. Exposed to the air, they slightly effloresce. When heated, they undergo the watery fusion, evolve their water of crystallization, and are decomposed: the residue consists of charcoal and the carbonates of potash and soda. They are readily soluble in cold, and still more so in hot water.

FIG. 96.



Prism of Rochelle Salt.

FIG. 97.



Natural Half of ditto.

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[1] Beckmann's *Hist. of Invent.* vol. iv. p. 616.

Characteristics—This salt may be recognized by the shape and size of the crystals. Sulphuric acid added to the aqueous solution throws down small crystals of bitartrate of potash; perchloric acid throws down perchlorate of potash: bichloride of platinum produces a yellow precipitate (see *ante*, p. 463). When heated, Rochelle salt is decomposed, various volatile substances are evolved, and the odour of caramel is given out. If the residuum be digested in hydrochloric acid, we obtain a solution of the chlorides of sodium and potassium: the chloride of potassium may be precipitated by bichloride of platinum, leaving chloride of sodium in solution, which may be detected by the tests already mentioned for this salt (see *ante*, p. 523).

COMPOSITION.—The composition of this salt is as follows:—

	Ats.	*Eq.Wt.*	*P.Ct.*	*Schulze.*			*Ats.*	*Eq.Wt.*	*P.Ct.*
Soda	1	31	10·3	13·3	or	Tartrate Potash	1	114	37·8
Potash	1	48	15·9	14·3		Tartrate Soda	1	97	32·2
Tartaric Acid	1	132	43·8	41·3		Water	10	90	30·0
Water	10	90	30·0	31·1					
Crystl^d Tartrate of Potash and Soda	1	301	100·0	100·0			1	301	100·0

Dr. Thomson[1] says, that when the crystals are free from all adhering moisture, they contain only eight atoms (or 25·4 per cent.) of water of crystallization, and their equivalent weight is 283. Mr. R. Phillips also states that the water of crystallization is only eight atoms.

PHYSIOLOGICAL EFFECTS.—It is a mild, laxative, cooling salt, very analogous in its effects to the tartrate of potash. Sundelin[2] says it is uncertain as a purgative,—sometimes failing, at others acting very slowly, but strongly, and with violent abdominal pain. He thinks it may be completely replaced in practice by a mixture of magnesia and sulphate of magnesia. When given in the form of dilute solution, and so as not to excite purging, it becomes absorbed, and renders the urine alkaline (see *ante*, p. 180, for a notice of Laveran and Millon's experiments). Hence its use should be carefully avoided in persons suffering with phosphatic deposits in the urine.

USES.—It is commonly employed as a mild aperient for females and other delicate persons. It may be used with advantage by those who are subject to excessive secretion of lithic acid or the lithates.

ADMINISTRATION.—It is given in doses of from ʒij. to ʒvj. or ℥j. It should be exhibited largely diluted with water. A very convenient mode of exhibition is in combination with bicarbonate of soda and tartaric acid in an effervescing condition (vide *Seidlitz Powders*, p. 535).

69. SAPONES SODAICI ET POTASSICI.—SODA AND POTASH SOAPS.

HISTORY.—The term *soap* (*sapo*) is usually applied to a combination of one or more fatty acids with a salifiable oxi-base; but it has also been extended to a compound of a resinous acid with an alkali. The substances, therefore, which at the present time bear the name of soaps, may be thus arranged:—

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[1] *First Principles*, ii. 440.

[2] *Hand. d. Heilmittellehre.*

			EXAMPLES.
1. Fatty soaps	Soluble or alkaline	Ammoniacal	*Linimentum Ammoniæ*, Ph. L.
		Soda-soaps	*Sapo*, Ph. L.; *Sapo hispanicus.*
		Potash-soaps	*Sapo mollis*, Ph. L.
	Insoluble	Earthy	*Linimentum Calcis*, Ph. Ed.
		Metallic (plasters)	*Emplastrum Plumbi*, Ph. L.
2. Resinous soaps			*Sapo guaiacinus, &c.* Ph. Boruss.

On the present occasion it is intended to notice the soaps composed of fatty acids combined with potash or soda, and which constitute the *soaps commonly so called.* These substances, chemically speaking, are *oleates, margarates,* and *stearates of potash* or *soda* (*potassæ* vel *sodæ oleates, margarates,* et *stearates*).

The Hebrew word *borith,* translated in our version of the Bible[1] *soap,* is, by most commentators, supposed to refer to a plant, or to the alkaline ashes of some plant.

Pliny,[2] who mentions soap, says it was invented by the Gauls to render the hair golden-coloured. It is made, he adds, of tallow and ashes, the best being prepared with beech-wood ashes, and goats' tallow. He further states that there are two kinds of it—one thick (*sapo spissus*), the other liquid (*sapo liquidus*), both being used in Germany, but more by the men than by the women. In the excavations made at Pompeii, a complete soap-boiler's shop was discovered, with the soap still perfect, though it must have been manufactured for more than 1700 years.[3]

NATURAL HISTORY.—Soap is always an artificial product, unless the spontaneous formation of *adipocire* from dead animal matter be considered an exception to this statement. This substance appears, from the analysis of Chevreul, to consist of a small quantity of ammonia, of potash, and lime, united to much margaric acid and a very little oleic acid.

PREPARATION.—The following is a concise account of the principles of soap-making:—"In order to form soap, the oil or fat is boiled with a solution of caustic potash or soda, till the whole forms a thick, viscid emulsion, which can be drawn out into long, clear threads. If not clear, either water or alkali must be added, according as the turbidity depends on undecomposed oil, or on a deficiency of water. When the saponification is complete, the next step is to separate the soap from the excess of alkali, the glycerine, and the superfluous water. This may be effected by boiling down till the alkaline ley becomes very concentrated, when the soap becomes insoluble, and rises to the surface. The same end is attained by adding very strong ley or common salt, both of which render the soap insoluble when added in sufficient quantity; soap being absolutely insoluble in alkaline ley of a certain strength, as well as in a saturated solution of common salt. The separation is known to be complete when the liquid ceases to froth in boiling; and the soap is ladled off into moulds, where it is well stirred to favour the separation of the liquid, which should run off from its surface like water from fat. The soap brought to this state in the first operation is called *grain soap,* from its separating in grainy particles at first. It may be further purified by repeating the process of dissolving in alkaline ley, and separating it by the addition of salt. In this process the impurities subside, and the soap generally takes up more water; so that, although whiter, it is less strong. White soap, for example, commonly contains 45 to 60 per cent. of water; while grain soap contains 25 to 30 per cent. No doubt it may be again procured with as little water as at first; but it is the fluidity caused by the additional water that allows the impurities to subside, and the soap to become white. What is called *marbled* [or *mottled*] *soap* is grain soap which has not been subjected to purification; and the grey, blue, and green colours in it arise principally from the presence of insoluble soaps of oxide of iron or of copper.

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[1] *Jer.* ii. 22; and *Mal.* iii. 2.

[2] *Historia Naturalis,* lib. xxviii. cap. 51, ed. Valp.

[3] Parkes, *Chem. Essays,* ii. 5, 2d edit.

"It is to be observed, that when common salt is added to the solution of a soap of potash, the latter is converted into soda-soap, entirely or partially, according to the quantity of salt, while chloride of potassium is formed. As this latter salt does not cause the soap to separate, like common salt, it is necessary to use twice as much salt to separate the soap when it has been made with potash. If a soap of potash be required, it must be separated by caustic potash. In Germany, soda-soap is first made with potash, and the potash-soap is decomposed by common salt. In England and France, soda-soap is made directly with caustic soda.

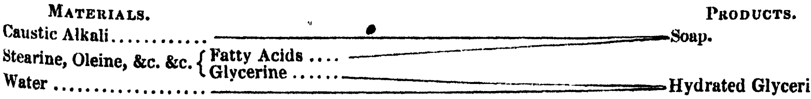
"The use of salt in this important process depends on the curious fact, that soap, like muscular fibre or animal membrane, cannot be moistened by a saturated solution of salt; that is, cannot deprive it of water. On the other hand, if these substances be moistened with water, or dissolved in it, the addition of dry salt in sufficient quantity will remove the whole of the water."[1]

THEORY OF SAPONIFICATION.—The fixed oils and fats, as they occur in nature, are for the most part mixtures or compounds of two or more fatty salts. *Stearine*, *margarine*, *oleine*, *cocinine* (or *coco-stearine*), *palmitine*, and *phocenine*, are the fatty salts of most frequent occurrence in the fats used for soap-making. They are each composed of—or, at least, are resolvable into—a sweet basic substance called *glycerine*, or the *oxide of glyceryle* (C^6H^7,O^5), and a fatty acid. Stearine yields *stearic acid*; margarine, *margaric acid*; oleine, *oleic acid*; cocinine, *cocinic acid*; palmitine, *palmitic acid*; and phocenine, *phocenic acid*.

Tallow consists chiefly of stearine with a little oleine. *Olive oil* is composed of margarine and oleine. *Almond oil* contains less margarine than olive oil. *Palm oil* contains oleine, margarine (?), and about two-thirds of its weight of a white solid fat, called palmitine. *Cocoa-nut oil* consists of coconine and oleine. *Train* or *fish oil* consists of oleine and phocenine.

When the oils and fats are acted on by a solution of the caustic alkali, the latter unites with the fatty acid, forming a soap, and disengages glycerine, which combines with water.

The following diagram illustrates the process of saponification:—



The phenomena observed during the action of resins on alkalies are different. Resins usually consist of one or more acids, which combine with alkalies to form resinous salts or soaps. Thus, ordinary yellow resin (or rosin) consists of two acids, called respectively pinic (chiefly) and silvic acids; and a soda soap made of this substance would, therefore, be a mixture of pinate and silvate of soda.

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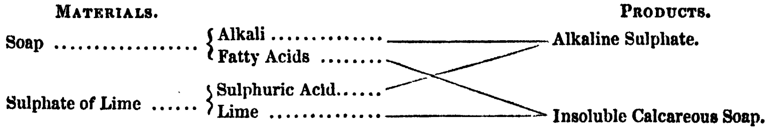
[1] Liebig, in Turner's *Elements of Chemistry*, 8th edit. p. 1118.

PROPERTIES.—The consistence, colour, odour, and sp. gr. of soap vary in the different varieties of this substance. The taste of all is slightly alkaline. All the alkaline soaps are soluble both in water and alcohol. The substance called *transparent soap* is prepared by evaporating an alcoholic solution of pure soap. When heated, soap fuses, swells up, and is decomposed, leaving a residuum of charcoal and alkaline carbonate. Most of the acids decompose soap: they unite with the alkaline base, and separate the fatty acids. The earthy salts (as sulphate of lime, sulphate of magnesia, alum, &c.) also decompose soap: the fatty acids unite with the earth to form an insoluble earthy soap, while the alkali of the soap combines with the acid of the salt. The *hardness* of sea, spring, and well water, depends on the earthy salts (principally sulphate of lime), which decompose soap (see *ante*, pp. 284-85): hence tincture of soap may be used as a test of the hardness or softness of common waters.

The following diagram explains the action of sulphate of lime on soap:—



The metallic salts decompose soap, and give rise to metalline insoluble soaps.

Characteristics.—Soap may be partly recognised by its physical properties, especially by its feel, which is so well known that it is usually called *soapy*. The solubility of soap in water and alcohol is an important character, as well as its detergent quality, which depends on its power of rendering fatty and other matters soluble in water. The effect of heat on it also deserves notice: if the carbonaceous residuum be digested in weak hydrochloric acid, and the solution filtered and concentrated by evaporation, the nature of the alkaline base may be ascertained by applying the tests for potash and soda before mentioned (see *ante*, pp. 463 and 523). Lastly, the action of acids and earthy and metallic salts on a solution of soap, as already noticed, serves to recognise soap.

VARIETIES.—A considerable number of soda and potash soaps are met with in commerce. Of these, some are *hard*, others *soft*; the former are prepared with soda, the latter with potash. This circumstance, therefore, forms the ground of their division into two classes.

Class 1. Hard or Soda Soap; *Sapo Sodaicus*; *Sapo natrinus*; *Sapo durus*; *Sapo spissus*, Pliny?—The qualities of the hard or soda soaps vary according to the nature of the fatty matters with which these substances are prepared.

1. CASTILE OR SPANISH SOAP; *Sapo*; *Sapo ex olivæ oleo et sodæ confectus*; *Sapo durus*; *Spanish or Castile Soap made with olive oil and soda*, E.; *Sapo durus*, D.; *Sapo Hispanicus*; *Sapo Castiliensis*; *Marseilles* or *Venetian Soap*; *Olive Oil Soda Soap*.—This is prepared with olive oil and a solution of caustic soda. When pure, it has very little odour. It is hard, but in the fresh state may be easily worked or kneaded between the fingers: by keeping in warm air it becomes dry and pulverizable. It should not feel greasy, have a rancid odour,

communicate an oily stain to paper, nor be covered with a saline efflorescence; but should dissolve completely and readily in both water and alcohol.

Two varieties of it are known in commerce—the *white* and the *marbled.*

a. White Castile Soap.—This is purer than the following variety, but it is a weaker soap (*i. e.* it contains more water).

β. Marbled Castile Soap.—This variety is harder than the white kind. The marbled appearance is produced by adding to the soap, as soon as it is completely made and separated from the spent lye, a fresh quantity of lye, and immediately after a solution of sulphate of iron. A precipitate (probably composed of black oxide of iron, sulphuret of iron, and iron-soap) is formed; and this gives the dark-coloured streaks to the soap. By exposure to the air these streaks become red, in consequence, probably, of the conversion of the black oxide into the red or sesquioxide of iron.

2. ALMOND SOAP; *Almond Oil Soda Soap; Sapo amygdalinus,* French Codex.—This is the medicinal soap of the French. It is prepared with ten parts of soap-boilers' lye (a solution of caustic soda) and twenty-one parts of almond oil.[1] In this country it is used as a toilet soap.

3. COMMON SOAP; *Sapo vulgaris,* United States Pharmacopœia; *Sapo sebaceus,* Geiger; *Animal Oil Soda Soap.*—This is prepared with tallow and soda. Two kinds of it are in common use, *curd soap* and *mottled soap.*

a. White Curd Soap.—This is made with pure or white tallow and soda. *White Windsor Soap* belongs to this class of soaps. It is said to be made with one part of olive oil and nine parts of tallow; and scented.

β. Mottled Soap.—This is the common or domestic soap. Refuse kitchen grease, called *kitchen stuff,* is used in its preparation.

4. YELLOW SOAP; *Rosin Soap; Resin Soda Soap.*—This is prepared with tallow, rosin, and caustic soda. Palm oil is also frequently employed in its manufacture.

5. COCOA-NUT OIL SOAP; *Marine Soap.*—This is prepared with cocoa-nut oil (usually mixed with tallow) and soda. It is used for washing with sea water.

In addition to the preceding there are several other varieties of soda-soap found in commerce. *Toilet* or *fancy soap* consists essentially of one of the preceding kinds of soap, mixed with some fragrant volatile oil. *Silica soap* is a hard soap, with which silicate of soda is incorporated. *Sand soap* is common soap intermixed with sand. The term *clay soap* may be given to proposed mixtures of common soap with pipe-clay, fuller's-earth, soap-stone, or porcelain earth. *Chlorine soap* is intended to be soap mixed or combined with an alkaline hypochlorite (?). *Bone soap* consists of ordinary soap intermixed with bone-gelatine dissolved in caustic potash: it is said to be sold under the name of *Liverpool poor man's soap.*[2]

2. Of Soft or Potash Soap; *Sapo potassicus; Sapo kalinus; Sapo mollis; Sapo liquidus,* Pliny?—This kind of soap is made with caustic potash and oil or fat.

1. COMMON SOFT SOAP; *Sapo mollis,* D.; *Animal Oil Potash Soap.*—This is prepared with fish oil (whale, seal, or cod), tallow, and potash. Its colour is brownish or yellowish; transparent, interspersed with white specks or grains of stearic soap formed by the tallow, and which give the soap a granular texture like that of the fig.

2. OLIVE OIL POTASH SOAP; *Sapo mollis,* L. E.; *Sapo ex olivæ oleo et potassâ confectus,* L.; *Soft Soap made with olive oil and potash,* Ed.—This is ordered in the London and Edinburgh Pharmacopœias, but is rarely met with.

COMPOSITION.—The following is the composition of several varieties of soap[3]:—

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[1] Soubeiran, *Nouveau Traité de Pharmacie,* t. ii. p. 582, 2nde édit.

[2] For further details, see Knapp's *Chemical Technology.*

[3] See Gmelin's *Handbuch der Chemie.*

HARD OR SODA SOAPS.

Constituents.	Marseilles White.		Marseilles Marbled.	Foreign Castile, very dry. Sp. Gr. 1·0705.	London-made Castile, very dry. Sp. Gr. 0·9669.	Glasgow White Soap.	Cocoa-nut Oil Soap. (Marine Soap.)
	(*Braconnot.*)	(*D'Arcet.*)	(*Thenard.*)	(*Ure.*)	(*Ure.*)	(*Ure.*)	(*Ure.*)
Soda	10·24	6	6	9·0	10·5	6·4	4·5
Fatty Acids	68·40	60	64	76·5	75·2	60·0	22·0
Water..............	21·36	34	30	14·5	14·3	33·6	73·5
Hard or Soda Soap..	100·00	100	100	100·0	100·0	100·0	100·0

SOFT OR POTASH SOAPS.

Constituents.	London Soft Soap.	Glasgow Soft Soap.
	(*Ure.*)	(*Ure.*)
Potash	8·5	9·0
Fatty Acids	45·0	43·7
Water..............................	46·5	47·3
Soft or Potash Soap	100·0	100·0

PURITY.—The adulterations of soap are excess of water, lime, gypsum, or pipe-clay. The first may be known by the consistence of the soap, and the great loss of weight which this substance undergoes in dry air. The other impurities may be detected by alcohol, which leaves them undissolved.

PHYSIOLOGICAL EFFECTS. α. *On Vegetables.*—Soap, used as a manure, appears to promote vegetation.[1]

β. *On Animals.*—It does not appear to be poisonous to animals. Veterinarians employ it as a diuretic, and, in large doses, as a purgative.

γ. *On Man.*—Soap acts very much like the alkalines, before noticed (see *ante*, p. 177). Its local operation, however, is much less energetic than either the caustic or even the carbonated alkalies. Hence it may be administered in considerable doses without causing irritation or inflammation. When swallowed, it very readily palls the appetite and disturbs the digestive functions. Perhaps these effects depend on the separation of the fatty acids in the stomach. Probably the fatty acids become more or less completely digested, for soap acts on the general system like the alkalies;—it promotes the secretion of urine, and communicates alkaline properties to this fluid. In large doses it acts as a purgative. I knew an idiot who had frequently eaten large lumps of soap without any ill effects; and I have heard of a pound of it being swallowed for a wager!

USES.—As an *antacid*, soap is employed in poisoning by the mineral acids: it should be administered in the form of a strong solution, which effectually neutralizes the acid without acting as an irritant. So also in those forms of dyspepsia which are attended with an excessive formation of acid, soap may be usefully employed to neutralize it. External parts burnt with the strong mineral acids, or with phosphorus, should be washed with a solution of soap. As a *lithonlytic*, soap has been used in those forms of lithiasis in which uric acid prevails (see *ante*, p. 259). A mixture of soap and lime-water was once considered a most powerful solvent for urinary calculi. The Hon. Horace Walpole[1] gained great relief from it. By the action of lime-water on it, an insoluble calcareous soap and a solution of caustic soda are formed. As a *purgative*, soap is rarely exhibited alone: in combination with rhubarb, it may be employed with considerable benefit in habitual constipation and disordered conditions of the biliary functions. In the form of enema, a strong solution of it is sometimes used with great relief to dissolve hardened fæces, and to relieve obstinate constipation. As a *resolvent* or *alterative*, it was once much esteemed in enlargements and various chronic disorders of the viscera and glands; and, as the alkalies have been found useful in the same diseases, any good effects which may have been obtained by it are probably referable to its alkaline base.

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[1] De Candolle, *Physiol. Végét.* p. 1343.

Externally, soap is frequently employed on account of its detergent, lubricating, and discutient qualities. Thus, in tinea capitis, scabies, and various other skin diseases, ablution night and morning with soap-water greatly contributes to the cure. On account of its lubricating qualities, it is a most convenient adjunct to liniments. The use of the liniment, cerate, and plaster of soap, are noticed below.

Lastly, soap is used in pharmacy to render other medicines more soluble, or to give a proper consistence to various substances for the making of pills. Thus it is a constituent of various pills (e. g. *Pilulæ Rhei compositæ; Pilulæ Saponis compositæ;* and *Pilulæ Scillæ compositæ*). In some cases it acts as the *adjuvans*, assisting and promoting the operation of other medicines; as a *corrigens*, correcting their operation; and as a *constituens*, imparting an agreeable or convenient form. The addition of soap to aloes or extract of jalap is cited by Dr. Paris[2] as an instance in which soap fulfils all three of these objects.

ADMINISTRATION.—The usual dose of soap, taken in a pilular form, is from grs. v. to ʒss. In cases of poisoning by the mineral acids, half a pint of strong solution of soap should be instantly administered.

1. LINIMENTUM SAPONIS, L. E. D.; *Soap Liniment; Opodeldoc.*—(Soap, ʒiij.; Camphor, ℥j.; Spirit of Rosemary, f℥xvj. *L. D.* Castile Soap, ʒiv.; Camphor, ʒij.; Volatile Oil of Rosemary, fʒv.; Rectified Spirit, Oj. and f℥xij. *L.*—Castile Soap, ℥v.; Camphor, ℥ijss.; Volatile Oil of Rosemary, f℥vj.; Rectified Spirit, Oij. *E.*—Soap, ℥iij.; Camphor, ℥j.; Spirit of Rosemary, f℥xvj. *D.* The London College orders the camphor to be dissolved in the spirit, and the soap to be added afterwards; but the Edinburgh and Dublin Colleges direct the soap to be first dissolved, and the camphor [and oil, *E.*] subsequently. The Edinburgh College orders the mixture to be agitated briskly).—If made with hard soap, as directed by the Pharmacopœias, this preparation is apt to solidify in cold weather. On this account druggists usually substitute common soft soap. The only objection to this is its unpleasant smell. Soap liniment is used as a stimulant and discutient, as well as, on account of its lubricating qualities, in local pains, sprains, bruises, rheumatism, &c. It is a constituent of *Linimentum Opii.*

2. CERATUM SAPONIS, L.; *Soap Cerate.*—(Soap, ʒx.; Wax, ʒxiiss., Oxide of Lead, powdered, ʒxv.; Olive Oil, Oj.; Vinegar, *Cong.* j. Boil the vinegar with the oxide of lead over a slow fire, constantly stirring them until they incorporate; then add the soap, and boil again in like manner,

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[1] *Philosophical Transactions*, xlvii. 43 and 472.

[2] *Pharmacologia.*

until all the moisture is evaporated; lastly, with these mix the wax, first dissolved in the oil.) The subacetate of lead, formed by boiling the oxide of lead with vinegar, is decomposed by the soap, the soda of which combines with the acetic acid, and the fatty acids with the oxide of lead. The wax and oil serve to give consistence to the preparation. It is used as a mild cooling dressing for scrofulous swellings, and other local inflammations, as well as for fractured limbs: in the latter case, its principal use is as a mechanical support.

3. **EMPLASTRUM SAPONIS,** L. E. D.; *Soap plaster*.—(Soap, sliced, lb.ss.; Litharge Paster, lb.iij. *L. D.*—Litharge Plaster, ℥iv.; Gum Plaster, ℥ij.; Castile Soap, in shavings, ℥j. *E.* Mix the soap with the liquefied plaster, and boil down to a proper consistence). The quantity of soap here ordered is said by Mr. Scanlan[1] to be too much by one half; as when prepared by the formula of the London and Dublin Pharmacopœias it is quite pulverizable, and falls into crumbs. The gum plaster ordered by the Edinburgh College will tend to obviate this defect. Boiling is unnecessary. This plaster, spread on leather, is used as a discutient and mechanical support.

4. **EMPLASTRUM SAPONIS COMPOSITUM VEL ADHÆRENS,** D.; *Adhesive Plaster*.—(Soap Plaster, ℥ij.; Litharge Plaster with Resin, ℥iij. Make a plaster, which should be melted and spread on linen). This plaster is less apt to irritate than the litharge plaster with resin, "owing to the much smaller proportion of resin. It is a very useful application to those abrasions of the skin which take place in consequence of long confinement to bed."[2]

ORDER XIII. COMPOUNDS OF LITHIUM.

Lithium (L=6·5) is the metallic base of the alkali *lithia* (so called from λίθειος, because it is exclusively found in the mineral kingdom). It is a constituent of several minerals (*petalite, triphane* or *spodumene, lepidolite, amblygonite,* &c). It is also found in many mineral waters, in most of which it has been found in the state of carbonate: but in the Pyrmont and Sliatsch waters it exists in the form of sulphate; in the Kreuznach waters as the chloride; and in the waters of Aix-la-Chapelle and Burtscheid it is found in combination with phosphoric acid and soda. The medicinal properties of the compounds of lithium are unknown. The carbonate is the only one of them which it has been proposed to employ therapeutically.

70. Lithiæ Carbonas.—Carbonate of Lithia.

Formula LO,CO^2. *Equivalent Weight* 36·5.

Found in many mineral waters; as those of Franzensbad, Klausen, Lubien, Ems, Teplitz, Bilin, Marienbad, Kissingen, Salzbrunn, Buchsäuerling, and Karlsbad.

Obtained by adding a strong solution of carbonate of ammonia to a solution of either sulphate of lithia or chloride of lithium. Or by decomposing sulphate of lithia by acetate of baryta, and calcining the resulting acetate of lithia, by which it is converted into the carbonate.

As usually met with, carbonate of lithia is a white powder, like carbonate of magnesia.

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[1] Dr. Montgomery, *Observations on the Dublin Pharmacopœia*, p. 596.

[2] *Ibid.* p. 597.

It has a slight alkaline taste, and is soluble in water, both hot and cold; but insoluble in alcohol. When it has been fused, it is more difficultly soluble in water than when it is in the pulverulent condition. About one hundred parts of cold water are said to dissolve one part of carbonate of lithia. It dissolves more readily in water holding in solution carbonic acid, by which bicarbonate of lithia is formed. It is in this state, probably, that it exists in many mineral waters. By dissolving carbonate of lithia in hot water, filtering and slowly evaporating the solution, crystals of the carbonate are formed: they are said to be anhydrous. A solution of one part of the carbonate in 1000 parts of water has an alkaline reaction.

Carbonate of lithia has the following composition:—

	Atoms.	*Eq. Wt.*	*Per Cent.*	*Hermann.*	*Schaffgotsch.*
Lithia	1	14·5	39·726	39	39·83
Carbonic Acid	1	22	60·274	61	60·17
Carbonate of Lithia	1	36·5	100·000	100	100·00

No experiments have hitherto been made to ascertain the effects of carbonate of lithia when swallowed; they are at present, therefore, unknown. On account of its difficult solubility, its local action is not very energetic. Like the other alkaline carbonates, carbonate of lithia doubtless becomes absorbed, and is eliminated by the kidneys. Analogy would also lead us to infer that it is capable of rendering the urine alkaline.

Although it is a constituent of many mineral waters, several of which are extensively consumed, its influence in them is quite unknown. It probably imparts very little activity to them, on account of the very minute proportion of it which they contain.

Attention has of late years been drawn to carbonate of lithia as a solvent for uric or lithic acid by Lipowitz,[1] Mr. Alexander Ure,[2] and Binswanger.[3] Lipowitz states, that one part of carbonate of lithia in 90 parts of water dissolved one part of uric acid at 122° F.; or four parts of uric acid at 212° F.: a solution of urate of lithia is formed while carbonic acid is evolved. Mr. Ure found that one grain of carbonate of lithia, dissolved in an ounce of distilled water, took up, at 98° F. (the heat of the blood), 2·3 grains of uric acid: and he says, that a human urinary calculus, composed of uric acid with alternate layers of oxalate of lime, lost five grains in weight by digestion for five hours in a solution of four grains of carbonate of lithia in an ounce of distilled water, at a blood-heat. And Binswanger states, that one part of carbonate of lithia, dissolved in 120 parts of water, takes up, at blood-heat, nearly four parts of uric acid. From the experiments of both Ure and Binswanger it appears that carbonate of lithia is a better solvent for uric acid, than either borax or the alkaline carbonates.

Mr. Ure has suggested the injection of a solution of carbonate of lithia into the urinary bladder as a lithonlytic, in calculi composed wholly or in part of lithic acid. "Of all the various menstrua hitherto recommended," says Mr. Ure, "none appears to promise more favourably than the carbonate of lithia, from the promptitude and energy with which, in dilute solution, it attacks calculi of this description. If by means of injections we can reduce a stone at the rate of a grain or more an hour, as the above experiment would lead us to anticipate, we shall not merely diminish the positive bulk of the calculus, but further loosen its cohesion, disintegrate it, so to speak, causing it to crumble down, and be washed away in the stream of urine. Cases may present themselves in which it may be expedient to conjoin the use of the lithontriptor; but only occasionally, and at long intervals. It is the frequency of repetition which renders that instrument so hazardous. It may be presumed, moreover, that the plan of throwing in a weak solution of this kind would generally exercise a beneficial influence in obviating irritation, by removing the sharp angular points and asperities of the broken fragments, where the practice of crushing is adopted."

It is probable that the internal employment of the carbonate of lithia might be resorted to with advantage in uric acid deposits. Aschenbrenner says it may be given in doses of from five to ten grains daily.

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[1] *Ann. der Chem. u. Pharm.* xxxvii. 348; and *Pharm. Central-Blatt für* 1841, p. 545.

[2] *Pharmaceutical Journal*, vol. iii. p. 74, 1843.

[3] Buchner's *Repertorium für die Pharmacie*, Bd. xlix. S. 199, 1848.

ORDER XIV. COMPOUNDS OF BARIUM.

Barium (Ba=69) is the metallic basis of the alkaline earth *baryta* (so called from βαρύς, *heavy*, on account of its great weight).

71. Barii Oxydum.—Oxide of Barium or Baryta.

Formula BaO. *Equivalent Weight* 77.

Baryta, also called *barytes*, or *heavy earth* (*terra ponderosa*), is the *protoxide of barium*, It is a greyish white or porous substance obtained by igniting nitrate of baryta. Its sp. gr. is about 4·7322. It forms with water a solid *hydrate of baryta* (BaO,HO), which is soluble in 20 parts of water at 60°, or 2 parts at 212°. From the hot solution *crystallized hydrate of baryta* (BaO,9HO) may be obtained.

Baryta water (*aqua barytæ*) is used as a test for both carbonic and sulphuric acids, with each of which it forms a white precipitate; that with sulphuric acid being insoluble in nitric acid.

Baryta combines with acids to form salts, several of which are used in medicine. Their chemical characteristics are as follows:—With the exception of the sulphate, all the barytic salts are soluble either in water only, or in dilute hydrochloric or nitric acid, and their solutions yield, with sulphuric acid or sulphate of soda, a white precipitate (BaO,SO^3) insoluble in nitric acid. The soluble barytic salts also furnish, with carbonate of soda, a white precipitate (BaO,CO^2). They likewise communicate a greenish yellow tint to the flame of either alcohol or pyroligneous spirit.

The characteristics of sulphate of baryta will be stated hereafter (see p. 574).

All the salts of baryta capable of solution in water or the juices of the alimentary canal are poisonous (see *barii chloridum*, and *barytæ carbonas*). Sulphate of baryta being insoluble is harmless: hence the antidote for baryta and its soluble salts is a solution of an alkaline sulphate, as sulphate of soda or sulphate of magnesia, or alum, by which the soluble barytic salt is converted into the insoluble sulphate (see *barytæ carbonas*, p. 574).

72. BARYTÆ CARBONAS.—CARBONATE OF BARYTA.

Formula BaO,CO^2. *Equivalent Weight* 99.

HISTORY.—In 1783, Dr. Withering recognised the native carbonate, which has, in consequence, been called, after its discoverer, *Witherite*.

NATURAL HISTORY.—It is peculiar to the mineral kingdom.

Witherite occurs in the lead-mines of the North of England; as of Anglesark, in Lancashire. *Baryto-Calcite*, a compound of carbonate of lime and carbonate of baryta, is met with at Alston Moor, Cumberland.[1]

PREPARATION.—The native carbonate of baryta is sufficiently pure for the preparation of the other barytic salts, and is the kind meant in the London Pharmacopœia.

Absolutely pure carbonate may be prepared by the addition of a pure alkaline carbonate to a solution of chloride of barium.

It may also be obtained by igniting (or boiling in water) finely-powdered sulphate of baryta with three parts of carbonate of potash, or carbonate of soda, and washing away the resulting alkaline sulphate.

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[1] For some curious anecdotes respecting its discovery at this place, see Parkes's *Chemical Essays*, vol. i. p. 324, 2d edit. London, 1823.

PROPERTIES.—Native carbonate of baryta occurs massive, stalactitic, and crystallized. Its crystals belong to the right prismatic system. The sp. gr. of this mineral is 4·3. Heated before the blow-pipe, it melts into a white enamel, with the evolution of much light, and the loss of carbonic acid. Artificially prepared carbonate is a fine, tasteless, odourless powder. It is almost insoluble in both hot and cold water; 4304 parts of cold, or 2304 parts of hot, water being required to dissolve one part of carbonate. It is more soluble in carbonic acid water.

Characteristics.—It dissolves with effervescence in hydrochloric acid: the evolved gas is carbonic acid (see *ante*, p. 319). The solution is known to contain a barytic salt ($BaCl$) by the test for this class of salts (see *ante*, p. 572).

COMPOSITION.—The following is the composition of this salt:—

	Atoms.	*Eq. Wt.*	*Per Cent.*	*Schaffgotsch.*	*Berzelius.*	*Berard.*
Baryta	1	77	77·7	77·63	77·9	78
Carbonic Acid	1	22	22·2	22·37	22·1	22
Carbonate Baryta	1	99	99·9	100·00	100·0	100

PURITY.—It should be white, odourless, tasteless, and entirely soluble in hydrochloric or nitric acid, by which its freedom from sulphate of baryta is demonstrated. Neither caustic ammonia nor hydrosulphuric acid should produce any precipitate or change of colour in the hydrochloric solution, by which the absence of alumina and metallic matter (lead or iron, or copper) may be inferred. If excess of sulphuric acid be added to this solution, the whole of the baryta is thrown down in combination with the acid, and no precipitate should be occasioned by the subsequent addition of carbonate of soda, by which the absence of lime is shown.

Totally soluble in diluted hydrochloric acid. This solution, on the addition of ammonia or hydrosulphuric acid, does not give any precipitate, and it remains colourless; when more sulphuric acid is added than is necessary to saturation, nothing is afterwards thrown down by carbonate of soda.—*Ph. Lond.*

"One hundred grains dissolved in an excess of nitric acid are not entirely precipitated with sixty-one grains of [anhydrous] sulphate of magnesia [or one hundred and twenty-five grains of the crystallized sulphate of magnesia]."—*Ph. Ed.*

PHYSIOLOGICAL EFFECTS. α. *On Vegetables.*—Germination does not take place in carbonate of baryta.[1]

β. *On Animals.*—Cows and fowls have been destroyed by swallowing the native carbonate.[2] Orfila[3] says a drachm of the powder killed a dog in six hours; but C. G. Gmelin[4] gave two drachms to a dog: vomiting took place, and the animal was well the next day. A drachm killed a rabbit in three hours. When applied to a wound it has proved fatal.[5] From the above experiments carbonate of baryta appears to act as an acro-narcotic poison: when swallowed it causes vomiting, inflames the alimentary tube, becomes absorbed, and acts specifically on the nervous system, causing convulsions, paralysis, and insensibility.

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[1] Vogel, in De Candolle, *Phys. Végét.* p. 1341.

[2] Parkes, *Chem. Essays*, vol. i. p. 330.

[3] *Toxicol. Générale.*

[4] *Versuche über d. Wirk. des Baryts*, &c. p. 8.

[5] Campbell, quoted by Christison, *Treatise on Poisons*, 3d edit. p. 532.

γ. On Man.—Only one case illustrating its action on the human subject has been published.[1] A young woman swallowed half a tea-cupful of the powdered carbonate: in two hours she had dimness of sight, double vision, ringing in the ears, pain in the head, and throbbing in the temples, a sensation of distension and weight at the epigastrium, distension of stomach, and palpitation. Subsequently she had pains in the legs and knees, and cramps in the calves. A day or two after, the cramps became more severe. These symptoms, slightly modified, continued for a long time.

USES.—Carbonate of baryta is employed in the preparation of the chloride of barium. It is not administered as a medicine.

ANTIDOTE.—A mixture of an alkaline sulphate (sulphate of soda or sulphate of magnesia) and diluted vinegar. (The use of the vinegar is to yield a soluble barytic salt, $BaO,\bar{A}$, on which the alkaline sulphate immediately reacts, and produces the insoluble sulphate of baryta).

73. BARYTÆ SULPHAS.—SULPHATE OF BARYTA.

Formula BaO,SO^3. *Equivalent Weight* 117.

HISTORY.—Native sulphate of baryta, called *ponderous* or *heavy spar* (*spathum ponderosum*), was formerly confounded with sulphate of lime. In 1774, Scheele discovered baryta; and in the year following, Gahn analyzed heavy spar, and found that it was composed of sulphuric acid and baryta.

NATURAL HISTORY.—It is peculiar to the mineral kingdom.

It frequently occurs crystallized in forms belonging to the right prismatic system. The crystals are commonly tabular. The *straight lamellar heavy spar* forms splendid groups of crystals. It occurs in Cumberland, Durham, Westmorland, &c. The *curved lamellar heavy spar* is generally known as *cock's-comb barytes*. It is common in Scotland, Derbyshire, &c. *Compact* or *earthy sulphate of baryta* occurs in Staffordshire and Derbyshire, and is called *cawk*. The *Bolognese spar*, from Monte Paterno, near Bologna, is *radiated sulphate of baryta*.

PROPERTIES.—Sulphate of baryta has a density of from 4·41 to 4·67. It is inodorous and tasteless. When pure, it is, in the pulverulent form, quite white. The form of its crystals has been before noticed.

"White or flesh-red; heavy; lamellar; brittle."—*Ph. Ed.*

Characteristics.—Before the blow-pipe it decrepitates, but is not easily fused. "This difficult fusibility constitutes a good mark of distinction between this mineral and sulphate of lime or of strontian."[2] Ultimately it melts into a hard, white enamel. It is insoluble in nitric acid. Reduced to powder, mixed with charcoal, and ignited, it is converted into sulphuret of barium, which, on the addition of hydrochloric acid, evolves sulphuretted hydrogen, and yields a solution of chloride of barium. (See *ante*, p. 572, for the tests for the barytic salts.)

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[1] Dr. Wilson, *Lond. Med. Gaz.* vol. xiv. p. 487.

[2] Dr. Thomson, *Outlines of Mineralogy, Geology, and Mineral Analysis*, vol. i. p. 104, Lond. 1836.

COMPOSITION.—Sulphate of baryta has the following composition:—

	Atoms.	*Eq. Wt.*	*Per Cent.*	*Berzelius.*	*Klaproth.*
Baryta	1	77	65·8	65·643	66·7
Sulphuric Acid	1	40	34·2	34·357	33·3
Sulphate of Baryta	1	117	100·0	100·000	100·0

PHYSIOLOGICAL EFFECTS.—According to the experiments of Orfila,[1] it is inert.

USES.—Sulphate of baryta, on account of its cheapness, is the usual source from whence the other salts of baryta are obtained; and on this account it has been introduced into the Edinburgh and Dublin Pharmacopœias. In its pure state it is sometimes employed as a pigment.

74. BARII CHLORIDUM.—CHLORIDE OF BARIUM.

Formula BaCl. *Equivalent Weight* 104·5.

HISTORY.—This compound was discovered by Scheele in 1775. It was at first termed *terra ponderosa salita*, and afterwards *muriate* or *hydrochlorate of barytes* (*barytæ murias* vel *hydrochloras*).

PREPARATION.—All the British Colleges give directions for the preparation of this salt.

The formula of the *London College* is as follows:—Take Carbonate of Barytes, broken into small pieces, ℥x.; Hydrochloric Acid, Oss.; Distilled Water, Oij.—Mix the Acid with the Water, and add the Carbonate of Barytes gradually to them. Then, heat being applied, and the effervescence finished, strain and boil down the liquor, that crystals may be formed.

The *Edinburgh College* directs it to be prepared either in the same way as the London College, or as follows:—Take of Sulphate of Baryta, lb. ij.; Charcoal, in fine powder, ℥iv.; Pure Muriatic Acid, a sufficiency. Heat the sulphate to redness, reduce it to a fine powder, mix the charcoal with it thoroughly, heat the mixture in a covered crucible for three hours at a low white heat. Pulverize the product, put it gradually into five pints of boiling water; boil for a few minutes; let it rest for a little over a vapour-bath; pour off the clear liquor, and filter it if necessary, keeping it hot. Pour three pints of boiling water over the residuum, and proceed as before. Unite the two liquids; and, while they are still hot, or, if cooled, after heating them again, add pure muriatic acid gradually so long as effervescence is occasioned. In this process the solutions ought to be as little exposed to the air as possible; and, in the last stage, the disengaged gas should be discharged by a proper tube into a chimney or the ash-pit of a furnace. Strain the liquor, concentrate it, and set it aside to crystallize.

The *Dublin College* also prepares it from the sulphate. The process is as follows:—Take of Sulphate of Baryta, *ten parts;* Charcoal, reduced to the most subtle powder, or of Lampblack, *one part.* Let the Sulphate of Baryta be roasted in the fire, and whilst red hot thrown into water; then let it be reduced to the finest powder, in the manner directed for Prepared Chalk. Let the powders, intimately mixed together, be passed into a crucible, and exposed to a strong heat until they become red hot, during four hours. Let the mass, when cold, be dissolved in a quantity of boiling distilled water, amounting to ten times the weight of Sulphate of Baryta, and let the liquor be filtered. To this add, avoiding the vapours, as much muriatic acid as may be sufficient to saturate the baryta. Then let the liquors be filtered, from which, by evaporation and cooling, let crystals be formed.

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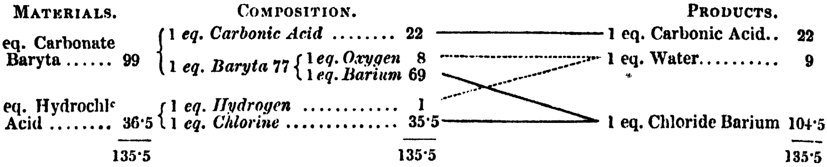
[1] *Toxicologie Générale.*

When hydrochloric acid and carbonate of baryta are mixed together, one equivalent of hydrochloric acid reacts on one equivalent of carbonate of baryta; and the products are—one equivalent of carbonic acid, which escapes; one equivalent of water; and one equivalent of chloride of barium. $BaO,CO^2 + HCl = BaCl + CO^2 + HO$.


MATERIALS.
COMPOSITION.
PRODUCTS.
1 eq. Carbonate Baryta...... 99
1 eq. Carbonic Acid........ 22
1 eq. Baryta 77
1 eq. Oxygen 8
1 eq. Barium 69
1 eq. Hydrochl^c Acid........ 36·5
1 eq. Hydrogen 1
1 eq. Chlorine .... 35·5
1 eq. Carbonic Acid.. 22
1 eq. Water.......... 9
1 eq. Chloride Barium 104·5
135·5
135·5
135·5

When a mixture of sulphate of baryta and charcoal is submitted to an intense heat, the carbon combines with the oxygen of the sulphuric acid and of the baryta, and forms carbonic oxide, which escapes. $BaO,SO^3 + 4C = BaS + 4CO$. The residue digested in water forms a solution of sulphuret of barium. On the addition of hydrochloric acid, hydrosulphuric acid gas is evolved, and the solution, by evaporation, yields crystals of chloride of barium. $BaS + HCl = BaCl + HS$.

PROPERTIES.—Chloride of barium crystallizes in right rhombic plates or tables, sometimes in double eight-sided pyramids, which belong to the right prismatic system. To the taste, this salt is disagreeable and bitter. Its sp. gr. is 3·097. In dry warm air the crystals effloresce, but in the ordinary states of the air they undergo no change. When heated, they decrepitate, lose their water of crystallization, and at a red heat fuse. At a white heat, according to Planiava, this salt volatilizes. It is soluble in both cold and hot water: 100 parts of water at 60° dissolve 43·5 of the crystallized salt,—at 222°, 78 parts. It is slightly soluble in ordinary rectified spirit, but is said to be insoluble in pure alcohol.

Characteristics.—(See the tests for the *chlorides* and *barytic salts*, pp. 369 and 572). Nitrate of silver added to a solution of chloride of barium causes a white precipitate (*chloride of silver*) soluble in ammonia, but insoluble in nitric acid. As a barytic salt, the chloride of barium is known by the following tests:—No precipitate is produced in a dilute solution of it by ammonia, hydrosulphuric acid, or ferrocyanide of potassium. But the soluble sulphates, phosphates, and carbonates, occasion with chloride of barium white precipitates (which are respectively *sulphate*, *phosphate*, and *carbonate of baryta*). The sulphate of baryta is insoluble in nitric acid. Chloride of barium communicates a greenish-yellow tint to flame.

COMPOSITION.—Crystallized chloride of barium has the following composition:—

	Atoms.	*Eq. Wt.*	*Per Cent.*	*Berzelius.*	*Phillips.*
Barium	1	69	56·326	85·201	85·5
Chlorine	1	35·5	28·980		
Water	2	18	14·694	14·799	14·5
Crystallized Chloride Barium	1	122·5	100·000	100·000	100·0

PURITY.—The crystals should be colourless, neutral to test paper, permanent in the ordinary states of the air (if they become moist or are deliquescent, the presence of chloride of calcium, or chloride of strontium, may be suspected), and their dilute aqueous solution should undergo no alteration of colour by the addition of ferrocyanide of potassium, hydrosulphuric acid, tincture of nutgalls, or caustic ammonia, by which the absence of metallic matter (as iron, lead, or copper) may be inferred. If excess of sulphuric acid be added, the filtered solution should be completely volatile when heated, and should occasion no precipitate on the addition of carbonate of soda, by which the absence of lime or magnesia is proved.

"One hundred grains in solution are not entirely precipitated by one hundred grains of [crystallized] sulphate of magnesia."—*Ph. Ed.*

PHYSIOLOGICAL EFFECTS. *a. On Vegetables.*—This salt is poisonous to plants.[1]

β. On Animals.—The action of chloride of barium on animals is, according to Sir B. Brodie,[2] analogous to that of arsenic. Locally, it operates as an irritant. After absorption, it affects the nervous system, the organs of circulation, and the stomach. Its action on the nervous system is manifested by staggering, convulsions, paralysis, and insensibility; on the circulating system, by palpitations, with feeble and intermittent pulse; on the stomach, by vomiting, from its application to a wound. According to Sir B. Brodie, the affection of the stomach is slighter than that caused by arsenic.[3] It is eliminated by the kidneys (see *ante*, p. 101).

γ. On Man.—Administered in *small doses*, it at first produces no very obvious effects. In some cases the appetite appears to be improved. Soon we observe an increased secretion of urine, tendency to sweating, and not unfrequently loose stools; so that it appears to operate as a liquefacient (see *ante*, pp. 175 and 179). With no other obvious symptoms than these, glandular swellings or enlargements sometimes become softer and smaller: hence it is resolvent. If we persevere in the use of gradually-augmented doses, the appetite becomes disordered, nausea and vomiting, with not unfrequently griping and purging, come on; a febrile state, with dry tongue, is produced, the nervous system becomes affected, and the patient complains of giddiness and muscular weakness. Sometimes, according to Schwilgué,[4] under the continued use of it, catarrhal discharges from the eye, nose, ear, &c. take place; inflamed or suppurating lymphatic glands evince signs of an augmented excitation; wounds assume a more healthy appearance, and, in some cases, cicatrize.

In *large medicinal doses* very unpleasant effects have been occasionally observed from its use; such as vomiting, purging, sometimes griping, contracted pulse, giddiness, and great muscular debility, almost amounting to paralysis, with trembling.[5]

In *excessive* or *poisonous doses* (as an ounce), the affection of the nervous system is more obvious. In one recorded case the symptoms were convulsions, pain in the head, deafness, and, within an hour, death.[6]

In conclusion, it may be observed, that considered medicinally, chloride of barium is most analogous to, though more powerful than, chloride of calcium, and is applicable in the same cases: regarded toxicologically, it may be compared to arsenic, but it acts less energetically on the stomach, and more rapidly on the nervous system, and causes death in a shorter time.

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[1] Marcet, quoted by De Candolle, *Phys. Végét.*

[2] *Phil. Trans.* 1812, p. 205.

[3] See also the experiments of Orfila in the *Toxicol. Génér.*, and of C. G. Gmelin in his *Versuche über die Wirkungen*, &c.

[4] *Traité de Mat. Méd.* vol. i. p. 441, 3me éd.

[5] See an illustrative case in *Medical Commentaries*, xix. 267.

[6] *Journal of Science*, vol. ix. p. 382.

USES.—The principal medicinal use of chloride of barium is in the treatment of *scrofula*, for which it was introduced into medicine by Dr. Crawford in 1790,[1] and was subsequently used by Hufeland[2] with great benefit. The latter writer has employed it in all the forms of this disease, but especially in excited and inflamed conditions (particularly of delicate and sensible parts, as of the lungs and eyes), in painful ulcers, indurations which are disposed to inflame, and cutaneous affections. It has also been administered as a resolvent, deobstruent, or alterative, in some other diseases; for example, *scirrhus* and *cancer*, *cutaneous diseases*, *bronchocele*, &c. As a local application, a solution of it has been used as a wash in herpetic eruptions, and as a collyrium in scrofulous ophthalmia.

In pharmacy and chemistry it is extensively employed as a test for sulphuric acid and the sulphates.

ADMINISTRATION.—It is used in the form of aqueous solution (see *liquor barii chloridi*).

ANTIDOTES.—The antidotes for the barytic salts are the sulphates, which form there with aninsoluble sulphate of baryta (see *ante*, p. 574). (In the absence of the alkaline sulphates, spring or well water which contains sulphate of lime may be copiously administered.) Of course the poison should be removed from the stomach as speedily as possible. To appease any unpleasant symptoms caused by the continued use of large medicinal doses, opiates may be employed.

LIQUOR BARII CHLORIDI, L.; *Solutio Barytæ Muriatis*, E.; *Barytæ Muriatis Aqua*, D.; *Solution of Chloride of Barium*. (Chloride of Barium, ʒj.; Distilled Water, f℥j.; L. E.—Muriate of Baryta, *one part*; Distilled Water, *three parts*, D. Dissolve.)—Dose of the solution of the London Pharmacopœia, ten drops, gradually and cautiously increased until nausea or giddiness is experienced. It is employed also as a test for sulphuric acid or the sulphates. Common water, and all liquids containing sulphates, carbonates, or phosphates, in solution, are incompatible with it.

75. Barii Iodidum.—Iodide of Barium.

Formula BaI. *Equivalent Weight* 195.

Hydriodate of Baryta (*Barytæ Hydriodas*).—Obtained by decomposing iodide of iron by either baryta or its carbonate; or by adding baryta to hydriodic acid. (See *Potassii Iodidum*.)—Iodide of barium is a white or greyish white mass. It is very soluble in water and in alcohol; and its aqueous solution yields by evaporation acicular crystals of the hydrated iodide of barium. By exposure to the air, iodide of barium suffers decomposition: it absorbs carbonic acid, and yields a coloured mass of carbonate of baryta and periodide (ioduretted iodide) of barium.—It is a violent poison, and requires great caution in its use. "*Caute, per deos, incede, latet ignis sub cinere doloso.*"[3] It is a violent local irritant and corrosive (more powerfully so than the chloride of barium). It has been employed in medicine as a powerful alterative, resolvent, and liquefacient, combining the effects of both baryta and iodine. It has been used in scrofulous and other swellings, in hypertrophies, chronic inflammation, &c.: in fact, in similar cases to those in which chloride of barium, iodine, and mercury, are given. The dose is ⅛th of a grain, very cautiously increased to one grain, three times daily, dissolved in distilled water. Biett employed the *unguentum barii iodidi* (composed of iodide of barium, gr. iv.; and lard, ℥j.) as an application to scrofulous swellings.

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[1] *Medical Commentaries*, Dec. 2d, vol. iv. p. 433, and *Medical Communications*, vol. ii.

[2] *Erfahr. üb. d. Gebr. u. d. Kräfte d. salzs. Schwererde*, Berl. 1794; and *Vollst. Darstell. d. med. Kräfte u. d. Gebr. d. salzs. Schwererde*, Berl. 1794.

[3] Jahn, quoted by Riecke, *Die neuern Arzneimittel*, p. 111, 1840.

76. BARYTÆ NITRAS.—NITRATE OF BARYTA.

HISTORY.—This salt was formed soon after the discovery of baryta.

PREPARATION.—It "is to be prepared like the muriate of baryta [chloride of barium, see *ante*, p. 575], substituting pure nitric acid for the muriatic acid."—*Ph. Ed.*

PROPERTIES.—It crystallizes in octohedrons. It is soluble in water, but insoluble in alcohol. It is decomposed, with decrepitation, by a bright red heat, and furnishes pure baryta.

Characteristics.—As a nitrate, it is known by the tests for this class of salts already mentioned (see *ante*, p. 412). The characters of the barytic salts have been before stated (see *ante*, p. 572).

COMPOSITION.—The crystallized salt is anhydrous. Its composition is as follows:—

	Atoms.	*Eq. Wt.*	*Per Cent.*	*Berzelius.*
Baryta	1	77	58·7	58·4
Nitric Acid	1	54	41·3	41·6
Nitrate of Baryta	1	131	100·0	100·0

PHYSIOLOGICAL EFFECTS.—Similar to those of the chloride of barium.

USES.—It is employed in chemistry and pharmacy as a test. Fire-work makers use it to communicate a green tinge to flame.

SOLUTIO BARYTÆ NITRATIS, E.; *Solution of Nitrate of Baryta.* (Nitrate of Baryta, 40 grs.; Distilled Water, 800 grs. Dissolve the salt in the water, and keep the solution in well-closed bottles.)—Employed as a test for sulphuric acid and the sulphates. It is analogous in its action to a solution of the chloride of barium; but is employed when it is considered desirable to avoid the presence of a metallic chloride.

ORDER XV. COMPOUNDS OF CALCIUM.

Calcium (Ca=20) is the metallic base of the alkaline earth, *lime*. It is extensively distributed in both the inorganic and organic kingdoms.

77. CALX.—LIME.

Formula CaO. *Equivalent Weight* 28.

HISTORY.—Lime, and the mode of obtaining it by burning the carbonate, were known in the most remote periods of antiquity. Hippocrates[1] employed this earth in medicine. Dr. Black, in 1755, first explained the nature of the process for making it. In 1808, Davy shewed that this substance was a metallic oxide; and hence it has been termed the *oxide of calcium*. It was formerly denominated *calcareous earth*. To distinguish it from the hydrate of lime, it is called *caustic lime*, or *quicklime* (*calx viva*), or *burned lime* (*calx usta*).

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[1] *Popularium*, ii. sect. 5.

NATURAL HISTORY.—It occurs in both kingdoms of nature.

α. IN THE INORGANISED KINGDOM.—In the mineral kingdom, lime is found in the form of carbonate, sulphate, phosphate, silicate, arseniate, tungstate, borate, and titanate. Its base, calcium, occurs in combination with fluorine. "Lime is also disseminated through sea-water, though in small quantities; so that calcium is widely distributed in land and water, being principally abundant in the central and higher parts of the fossiliferous rocks, and widely dispersed, in small quantities, throughout the more ancient rocks, and in the waters of the ocean."[1]

β. IN THE ORGANISED KINGDOM.—In vegetables, lime (or its basis, calcium) is an invariable ingredient, except, it is said, in the case of *Salsola Kali*.[2] It is found combined with carbonic, sulphuric, phosphoric, nitric, and various organic acids (as oxalic, malic, citric, tartaric, and kinic): calcium occurs in combination with chlorine. In animals, lime is found principally as carbonate and phosphate.

PREPARATION.—For use in the arts, lime is usually obtained by burning the compact limestone with coals, coke, and other fuel, in a kind of wind furnace, called a *kiln*.[3]

All the British Colleges admit as officinal the lime of commerce; but the London and Edinburgh Colleges also give directions for the preparation of pure lime.

The *London College* orders of Chalk, lbj. Break it into small pieces, and burn it in a very strong fire for an hour.

The *Edinburgh College* orders White Marble, broken into small fragments, to be heated "in a covered crucible at a full red heat for three hours, or till the residuum, when slaked and suspended in water, no longer effervesces on the addition of muriatic acid."

By the heat employed, the carbonic acid of the carbonate is expelled: one-half of the carbonic acid is expelled more easily than the other half; indicating the existence of a dicarbonate of lime, $=2CaO,CO^2$. It is well known that water, or a current of air, facilitates the escape of the carbonic acid: this effect is probably mechanical, and is due to the diffusion of one gas or vapour in another.[4] *Iceland spar*, or *white Carrara marble*, yields the purest lime.

PROPERTIES.—Lime (commonly termed *quicklime*, or *calx viva*), when pure, is a white or greyish solid, having a sp. gr. of about 3·0. A variety of commercial lime has a grey colour, and is called *grey lime*. Lime has an acrid, alkaline taste, and reacts powerfully on vegetable colours as an alkali. It is difficult of fusion; but by the oxy-hydrogen flame it may be both fused and volatilized. Exposed to the air, it attracts water and carbonic acid. If a small portion of water be thrown on lime, part of it combines with the lime, and thereby causes the evolution of a considerable degree of heat, by which another portion of the water is vaporized. The lime swells up, cracks, and subsequently falls to powder: in this state it is called *slaked lime* (*calx extincta*), or the *hydrate of lime* (*calcis hydras*, L.) By heat, the water may be again expelled.

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[1] De la Beche, *Researches in Theoretical Geology*, p. 21.

[2] De Candolle, *Phys. Végét.* p. 382.

[3] Vide Loudon's *Encyclopædia of Agriculture*, 3d edit. p. 625; Gray's *Operative Chemist*; and Ure's *Dict. of Arts*.

[4] See Gay-Lussac, in Jameson's *Journal*, vol. xxii. 1837.

Lime is slightly soluble in water. Its solubility in this liquid is very remarkable; cold water dissolving more than hot. According to Mr. Phillips,

A pint of Water at 32° dissolves 13·25 grains of Lime.
" " 60° " 11·6 "
" " 212° " 6·7 "

So that water at 32° dissolves nearly twice as much lime as water at 212°.

Characteristics.—An aqueous solution of lime is recognized by its reddening yellow turmeric paper, and rendering the infusion of red cabbage green; by the milkiness produced in it on the addition of carbonic acid, or a soluble carbonate; and by the white precipitate (*oxalate of lime*) on the addition of a solution of oxalic acid, or of an oxalate. Sulphuric acid affords no precipitate with lime water. Solutions of the calcareous salts are known by the following characters:—The hydrosulphurets, and, if the solution be dilute, the sulphates, occasion neither a precipitate nor a change of colour; the soluble carbonates, phosphates, and oxalates, produce white precipitates. The calcareous salts (especially chloride of calcium) give an orange tinge to the flame of alcohol.

COMPOSITION.—The following is the composition of lime and its hydrate:—

	Atoms.	*Eq.Wt.*	*Per Cent.*	*Berzelius.*		*Atoms.*	*Eq.Wt.*	*Per Cent.*	*Berzel.*
Calcium	1	20	71·43	71·91	Lime	1	28	75·676	75·7
Oxygen	1	8	28·57	28·09	Water	1	9	24·324	24·3
Lime	1	28	100·00	100·00	Hydrate of Lime	1	37	100·000	100·0

PURITY.—The lime used in the arts is never absolutely pure, but usually contains variable quantities of carbonate of lime, silica, alumina, and oxide of iron, and sometimes magnesia.

Water being added, it [lime] cracks and falls to powder. Its other properties are as hydrate of lime.—*Ph. L.*

It is slaked by water: muriatic acid then dissolves it entirely, without any effervescence; and the solution does not precipitate with ammonia in excess.—*Ph. Ed.*

PHYSIOLOGICAL EFFECTS. *a. On Vegetables.*—Quicklime is poisonous to plants. Notwithstanding this, however, it is used as a manure, its efficacy consisting chiefly in its chemical action on the organic matter of the soil.[1]

β. On Animals.—On dogs, Orfila[2] found that quicklime acted as a caustic poison, but not very energetically; and that it occasioned death by producing inflammation of the texture with which it comes in contact.

γ. On Man.—Quicklime, like the fixed alkalies, is a powerful escharotic. Its use in promoting the decomposition of the bodies of persons who have died of contagious diseases, or on the field of battle, and its employment by the tanner to separate the cuticle and hair from skins, sufficiently establish its causticity. Its escharotic and irritant action is well seen in the ophthalmia produced by the lodgement of small particles of lime in the eye.

When applied to suppurating or mucous surfaces, lime water checks or stops secretion, and produces dryness of the part: hence it is termed a desiccant (see *ante*, p. 158). In this it differs from the fixed alkalies.

When administered internally, it neutralizes the free acid of the gastric juice, diminishes the secretions of the gastro-intestinal membrane, and thereby occasions thirst and constipation. It frequently gives rise to uneasiness of stomach, disordered digestion, and not unfrequently to vomiting. After its absorption, it increases the secretion of urine, and diminishes the excessive formation or deposition of uric acid and the urates. With this exception, it does not, as the alkalies do, promote the action of the different secreting organs, but, on the other hand, diminishes it, and has in consequence been termed an astringent. But it does not possess the corrugating action of the astringent vegetables, or of many of the metallic salts; it is rather a drying remedy, or desiccant. In this respect lime differs from the alkalies, but is analogous to the oxide of zinc. Vogt[1] considers it to be intermediate between the two. Weickard and others have ascribed to lime an antispasmodic property: and if this be true, its relation to zinc is still further proved.

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[1] Johnston's *Lectures on Agricultural Chemistry.*

[2] *Toxicol. Générale.*

A power of exciting and changing the mode of action of the absorbent vessels and glands has been ascribed to lime water, and probably with foundation. At any rate, under the use of it glandular enlargements have become softer and smaller. In other words, it operates as a resolvent. Sundelin[2] says that the excessive use of lime does not, as in the case of the alkalies, bring about a scorbutic diathesis, but a general drying and constriction, analogous to that caused by zinc.

Lime, in large doses, acts as a poison: the symptoms in one case were thirst, burning in the mouth, burning pain in the belly, obstinate constipation, and death in nine days.[3]

Uses.—Quicklime has been employed as a *caustic*, but alone is now rarely resorted to. It is sometimes applied in the form of *potassa cum calce* (see *ante*, p. 471), and is a constituent of the ordinary depilatories (see *ante*, p. 157). As an *antidote*, lime water, in conjunction with milk, was recommended by Navier[4] in poisoning by arsenious acid. In the absence of more appropriate antidotes, lime water may be administered in poisoning by the common mineral and oxalic acids. As a *lithonlytic* it possessed at one time considerable celebrity, partly from its being one of the active ingredients of Miss Joanna Stephens' *Receipt for the Stone and Gravel* (see *ante*, p. 259), as well as from the experiments and reports of professional men. As an *antacid* in dyspepsia, accompanied by acidity of stomach, it is sometimes useful. "Mixed with an equal measure of milk, which completely covers its offensive taste, it is one of the best remedies in our possession for nausea and vomiting dependent on irritability of stomach. We have found a diet, exclusively of lime water and milk, to be more effectual than any other plan of treatment in dyspepsia, accompanied with vomiting of food. In this case one part of the solution to two or three of milk is usually sufficient."[5] In the dyspepsia of gouty and rheumatic subjects, and which is usually accompanied with a copious secretion of uric acid by the kidneys, I have seen lime water serviceable. As a *desiccant* or *astringent*, it is useful as a wash for ulcers attended with excessive secretion. In some scrofulous ulcers in which I have employed it, its power of checking secretion has been most marked. In diarrhœa, when the mucous discharge is great, and the inflammatory symptoms have subsided, lime water is useful as an astringent. As an injection in leucorrhœa and gleet, it sometimes succeeds where other remedies have failed. The internal use of lime water has also been serviceable in checking secretion from various others parts, as from the bronchial membranes, the bladder, &c.

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[1] *Pharmakodynamik.*

[2] *Heilmittellehre.*

[3] Christison, *Treatise on Poisons.*

[4] *Contre-poison de l'Arsenic*, &c. 1777, quoted by Richter, *Ausf. Arzneimittellehre.*

[5] *United States Dispensatory.*

Lime water has also been employed for various other purposes. Thus, as an antispasmodic, in hypochondriasis and hysteria, with habitual excessive sensibility of the nervous system, it has been found useful by Weickard.[1] It has also been given as an alterative in glandular enlargements and venereal affections, and to promote the deposit of bone earth in diseases accompanied with a deficiency of this substance. In skin diseases (tinea capitis, scabies, prurigo, &c.) it has been applied as a wash.

ADMINISTRATION.—From half an ounce to three or four ounces may be taken three times a day. As already mentioned, it may be conveniently administered in combination with milk.

1. **LIQUOR CALCIS**, L.; *Aqua Calcis*, E. D.; *Lime Water*. (Lime, lbss.; Distilled Water, Oxij. Upon the lime, first slaked with a little water, pour the remaining water, and shake them together; then immediately cover the vessel, and set it by for three hours: afterwards, keep the solution, with the remaining lime, in stoppered glass vessels; and, when it is to be used, take from the clear solution.—The *Edinburgh College* uses Lime *one part*, and Water *twenty parts*.—The *Dublin College* employs of fresh-burnt Lime *one part*, and Water *thirty-one parts*; one of which is to be hot, and added just to slake the lime, the other is to be cold, and is added afterwards).—Lime water is colourless and transparent; but, by exposure to the air, becomes covered with a film of carbonate of lime, which is deposited on the sides and bottom of the vessel, and is succeeded by another. Hence it should be preserved in well-stoppered vessels with some undissolved lime, and, when used, the clear liquor poured off. Its taste is unpleasant and alkaline, and it has an alkaline reaction on vegetable colours. The dose of lime water is from f℥ss. to f℥iij. or f℥iv. three times a day. It may be conveniently administered in milk. Its uses have been above stated.

2. **LINIMENTUM CALCIS**, E. D.; *Liniment of Lime; Carron Oil.* (Linseed Oil [Olive Oil, *D.*], Lime Water, of each equal measures; Mix and agitate them together.)—Linseed and olive oils are each composed of, or are converted into, oleic and margaric acids and glycerine. When mixed with lime water, an oleo-margarate of lime (*calcareous soap*) is formed. It has long been celebrated as an application to burns and scalds, and is employed for this purpose at the Carron Ironworks: hence one of its names. Though the Dublin College orders olive oil, it is almost invariably prepared with linseed oil. Turpentine is sometimes advantageously added to it.

78. CALCIS CARBONATES.—CARBONATES OF LIME.

Lime and carbonic acid combine together in several proportions, as follows:—

Dicarbonate	anhydrous	$2CaO,CO^2$.
	hydrated	$2CaO,CO^2HO$.
Neutral or Monocarbonate	anhydrous (*Calc Spar; Arragonite*)	CaO,CO^2.
	hydrated (crystals)	CaO,CO^2,SHO.
Supercarbonate (Bicarbonate?)		$CaO,2CO^2$?

Of these the neutral carbonate and the supercarbonate require to be noticed.

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[1] Richter's *Ausf. Arzneim.* iii. 585.

1. Calcis Carbonas. Neutral Carbonate of Lime.

Formula CaO,CO^2. *Equivalent Weight* 50.

HISTORY.—Some varieties of carbonate of lime were distinguished and employed in the most remote periods of antiquity. Marble was probably used for building 1050 years before Christ.[1] Pliny[2] tells us that Dipœnus and Scyllis were renowned as statuaries of marble in the 50th Olympiad (*i. e.* about 580 years before Christ). The *creta*, mentioned by Horace[3] and Pliny was probably identical with our chalk.[4]

NATURAL HISTORY.—Carbonate of lime occurs in both kingdoms of nature.

a. IN THE INORGANISED KINGDOM.—It forms a considerable portion of the known crust of the earth, and occurs in rocks of various ages. It is found in the inferior stratified rocks, but more abundantly in the different groups in the fossiliferous rocks, particularly towards the central and higher part of the series.[5]

In the crystallized form it constitutes *calcareous spar* and *arragonite*. The first of these is most extensively distributed, and presents itself under many hundred varieties of shapes.[6]

Granular carbonate of lime (the *granular limestone* of mineralogists) more commonly occurs in beds, but sometimes constitutes entire mountains. The whitest and most esteemed primitive limestone is that called *statuary marble*, or, from its resemblance to white sugar, *saccharoid carbonate of lime*. That from Carrara, on the eastern coast of the Gulf of Genoa, is the kind usually employed by the statuary, and being very pure, should be employed for pharmaceutical purposes: it is the *marmor* of the British Pharmacopœias.

Chalk constitutes the newest of the secondary rocks, and occurs abundantly in the southern parts of England. It lies in beds, and contains an abundance of marine as well as terrestrial organic remains. The upper part of a considerable portion of the chalk of England contains numerous flints, which are supposed to have once belonged to poriferous animals.[7] According to Schweitzer (*Mem. of the Chem. Society*), p. 29, April 5th, 1842), the chalk of the Brighton Cliffs consists in 100 parts of carbonate of lime, 98·57; carbonate of magnesia, 0·38; phosphate of lime, 0·11; protoxide of iron, 0·08; protoxide of manganese, 0·06; alumina, 0·16; silica, 0·64.

There are various other forms of carbonate of lime constituting the substances called by the mineralogists *schiefer spar, rock milk, earth foam, stalactitic carbonate of lime, anthraconite, oolite, pisolite, marl, tufa*, &c.

Carbonate of lime is an ordinary ingredient in mineral and common waters, being held in solution by carbonic acid, and, therefore, deposited when this is expelled by boiling or otherwise.

β. IN THE INORGANISED KINGDOM.—Carbonate of lime is found in some plants, and is obtained from the ashes of most. It is an abundant constituent of animals, especially of the lower classes. Thus in the Radiate animals we find it in the hard parts of Corals, Madrepores, &c.; in the Molluscs (as the oyster), it is in the shells. In the articulated animals it forms, with phosphate of lime, the crusts which envelop these animals (as the crab and lobster); and in the higher classes it is found in bone, but the quantity of it here is very small.

PREPARATION.—Several forms of carbonate of lime are employed in medicine—viz. *marble, chalk, precipitated carbonate of lime*, and *carbonate of lime from animals*. Most of these require to be submitted to some preparation before they are fitted for use.

1. Marble; *Marmor; Carbonas Calcis* (*dura*), L.; *Massive Crystalline Carbonate of Lime; White Marble*, E.; *Marmor album*, D.—This is employed for the preparation of carbonic acid (see *ante*, p. 318), and for other purposes. White or statuary marble from Carrara should be selected, on account of its freedom from iron. It requires no preparation.

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[1] 1 *Chron.* xxix. 2.

[2] *Hist. Nat.* xxxvi.

[3] *Sat.* iii. lib. 2.

[4] On the chalk of the ancients, consult Beckmann's *History of Invent.* i. 212.

[5] De la Beche, *Researches in Theoretical Geology*, 21.

[6] See Bournon's *Traité Complet de la Chaux Carbonatée*, Londres, 1808.

[7] Dr. Grant, *Lect. on Comp. Anat.* in the *Lancet*, Nov. 2, 1833.

2. Chalk; *Creta; Calcis Carbonas* (*friabilis*), L.; *Creta; Friable Carbonate of Lime; Chalk*, E.; *Creta alba*, D.—This is found in great abundance in the southern parts of England. It is ground in a mill, and the finer particles separated by washing them over in water, letting the water settle, and making up the sediment into flat cakes, which are dried in the air. In this state it is called *whiting*. All the British Colleges give directions for the preparation of chalk by elutriation. By this means it is separated from silicious and ferruginous particles. The product is called *prepared chalk* (*creta præparata*, L. E. D.) It is usually made up into little conical loaves.

The *London College* orders of Chalk, lbj.; Water, as much as may be sufficient; add a little Water to the Chalk, and rub it that it may become fine powder. Put this in a large vessel with the rest of the water; then stir it, and after a short interval pour off the supernatant water, still turbid, into another vessel, and set it by that the powder may subside; lastly, the water being poured off, dry this powder and keep it for use. In the same way shells, first freed from impurities and washed with boiling water, are prepared.

The direction of the *Edinburgh* and *Dublin Colleges* are essentially the same, except that no mention is made of the preparation of chalk from shells.

3. Precipitated Carbonate of Lime; *Calcis Carbonas præcipitatum*, D.; *Creta precipitata; Precipitated Chalk*.—Carbonate of lime prepared by precipitation is employed by some druggists in the preparation of *aromatic confection* and *tooth-powder*. For these purposes it is superior to the ordinary prepared chalk on account of its freedom from gritty particles. The Dublin College directs it to be employed in the preparation of the *hydrargyrum cum cretâ*, D. The following is the mode of obtaining it:—

Take of Solution of Muriate of Lime, *five parts*; add of Carbonate of Soda, dissolved in four times its weight of distilled water, three parts. Let the precipitate be mixed with water, and suffered to subside, and let this operation be three times repeated with a sufficiently large quantity of water: lastly, when collected, let the powder be dried on a chalk stone or on paper.—*Ph. Dub.*

It should be prepared with cold solutions, otherwise the deposit is finely granular.

Sometimes sulphate of lime is substituted for the precipitated carbonate.[1] The fraud may be readily detected by the addition of either hydrochloric or nitric acid: no effervescence takes place with sulphate of lime. If sulphate be mixed with carbonate of lime, the fraud may be detected as follows:—Digest in dilute hydrochloric acid until effervescence ceases: the carbonate will be dissolved, and the sulphate for the most part will be left undissolved. By boiling in water, a small portion of sulphate is dissolved, and, by the addition of chloride of barium to the solution, the presence of sulphuric acid may be recognised (see *ante*, p. 355).

The precipitate procured by adding carbonate of soda to the solution obtained by digesting animal charcoal in muriatic acid, has also been used for *creta precipitata*;[2] but the precipitate thus procured contains only 22 per cent. of carbonate of lime, the remainder being calcareous phosphate. The presence of the phosphate is easily recognised thus:—Digest in dilute hydrochloric acid, by which both carbonate and phosphate of lime are dissolved, and add to the solution *caustic* ammonia, which precipitates the phosphate only: carbonate of soda being added to the filtered liquor, throws down carbonate of lime.

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[1] *Pharmaceutical Journal*, vol. iii. p. 340, 1844.

[2] *Pharmaceutical Journal*, vol. iii. pp. 403 and 454.

4. Carbonate of Lime from Animals.—Carbonate of lime is obtained from various animal substances; as from oyster shells, crab's claws, crab's stones, and red coral. These substances yield carbonate of lime intimately blended with some phosphate of lime and animal matter.

α. PREPARED OYSTER SHELLS; *Testæ præparatæ*, L.—See *Ostr[illegible] edulis.*

β. PREPARED CRAB'S CLAWS; *Lapilli Cancrorum præparati; Chelæ Cancrorum præparatæ.*—See *Cancer Pagurus.*

γ. PREPARED CRAB'S STONES; *Lapides Cancrorum præparati; Prepared Crab's Eyes; Oculi Cancrorum præparati.*—See *Astacus fluviatilis.*

δ. PREPARED RED CORAL; *Corallium rubrum præparatum.*—See *Corallium rubrum.*

PROPERTIES.—Pure carbonate of lime is a tasteless, odourless solid. When heated to redness, in a current of air its carbonic acid is expelled, leaving quicklime. It is almost insoluble in water, one part of carbonate requiring 1600 parts of water to dissolve it. It is much more soluble in carbonic acid water: the solution reddens litmus, but changes the yellow colour of turmeric paper to brown; and by boiling, or exposure to the air, gives out its carbonic acid, by which the carbonate of lime is deposited.

Carbonate of lime is a dimorphous substance; that is, it crystallizes in two distinct and incompatible series of forms. Thus the forms of *calcareous spar* belong to the rhombohedric system, while *arragonite* belongs to the right rectangular prismatic system. According to Gustav Rose,[1] both calcareous spar and arragonite may be formed in the humid way, but the first at a lower, the latter at a higher, temperature:[2] in the dry way, calcareous spar alone is formed. Both minerals doubly refract the rays of light (see *ante*, p. 140, figs. 22 and 23).

Granular limestone (of which *white marble* is the purest kind) is massive, and consists of small grains of minute crystals, presenting a lamellar structure and brilliant lustre, but intersecting each other in every direction, and thereby giving a glimmering lustre to the mass.

Chalk is massive, opaque, when pure, white, and has an earthy fracture. It is usually soft to the touch, and adheres to the tongue.

Characteristics.—Carbonate of lime is recognized as a carbonate by the tests already mentioned for this class of salts (see *ante*, p. 319). As a calcareous salt it is known by the characters for lime (see *ante*, p. 581).

COMPOSITION.—Carbonate of lime has the following composition:—

	Atoms.	*Eq. Wt.*	*Per Cent.*	*Marcet.*	*Strömeyer.*	*Berz. & Ure.*
Lime	1	28	56	56·1	56·35	56·4
Carbonic Acid	1	22	44	43·9	43·65	43·6
Carbonate of Lime	1	50	100	100·0	100·00	100·0

PURITY.—Pure marble or chalk should be perfectly soluble, with effervescence, in diluted hydrochloric acid, by which the absence of silica is shown. Ammonia should not cause any precipitate with this solution, by which its freedom from alumina, oxide of iron, phosphate of lime, &c. may be inferred: should a solution of sulphate of lime throw down anything, by which [illegible]ence of baryta and strontian is proved.

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6 *nd Edinb. Phil. Mag.* June 1838.

7 Yorke states that the deposit made by water on the interior of a copper boiler is artificial *Proceedings of the Chemical Society*, No. 1).

Totally soluble in hydrochloric acid, with effervescence. From this solution, after it has been boiled, when ammonia is dropped in, it throws down nothing.—*Ph. Lond.*

"A solution of 25 grains in ten fluidrachms of pyroligneous acid,[1] when neutralized by carbonate of soda, and precipitated by 32 grains of oxalate of ammonia, continues precipitable after filtration by more of the test."—*Ph. Ed.*

PHYSIOLOGICAL EFFECTS.—The local effects of chalk are those of an absorbent, antacid, and mild *desiccant* (see *ante*, p. 158). When swallowed, it neutralizes the free acid of the gastric juice, and in this way alone must, by continued use, injure the digestive functions. It causes constipation—an effect commonly observed from the use of a few doses in diarrhœa. By the action of the free acids of the alimentary canal, it is converted into one or more soluble calcareous salts, which become absorbed. Hence the continued use of carbonate of lime is attended with the constitutional effects of the calcareous salts; and, consequently, the statements which have been made as to the influence of chalk over the lymphatic vessels and glands, and its effect in diminishing excessive secretion, may be correct. Sundelin[2] thinks it may even promote the deposit of bone-earth in diseases attended with a deficiency of this substance. Carbonate of lime, prepared from animal matter, has been erroneously supposed to be more digestible than chalk, and, therefore, less likely to occasion dyspeptic symptoms.[3] Dr. A. T. Thomson[4] says, that "after chalk has been used for some time, the bowels should be cleared out, as it is apt to form into hard balls, and to lodge in the folds of the intestines.

USES.—As an *absorbent* and *desiccant*, prepared chalk is used as a dusting powder in moist excoriations, ulcers, the intertrigo of children, burns and scalds, erysipelatous inflammation, &c. In the form of ointment, it has been recommended by Mr. Spender[5] in ulcers.

As an *antacid*, it is exhibited in those forms of dyspepsia accompanied with excessive secretion of acid; and as an antidote in poisoning by the mineral and oxalic acids.

It has also been used in some diseases which have been supposed to depend on, or be accompanied by, excess of acid in the system—as in gouty affections, which are usually attended with the excessive production of uric acid, and in rachitis, which some have ascribed to a preponderance of phosphoric acid, or to a deficiency of lime in the system.

To diminish alvine evacuations, it is employed in diarrhœa. Its efficacy can hardly be referred solely to its antacid properties, for other antacids are not equally successful; but to its desiccating properties already referred to. Moreover, in many cases of diarrhœa in which chalk is serviceable, no excess of acidity can be shown to exist in the bowels. Aromatics are useful adjuncts to chalk in most cases of diarrhœa. In old obstinate cases, astringents (as logwood, catechu, or kino) may be conjoined with great advantage; and in severe cases, accompanied with griping pains, opium.

ADMINISTRATION.—Prepared chalk is given in the form of powder or mixture, in doses of from gr. x. to ʒj. or ʒij. It enters into a considerable number of officinal preparations.

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[1] This quantity of acid is unnecessarily large. According to Mr. Phillips (*Lond. Med. Gaz.* N. S. vol. ii. 1838-9, p. 759), it is capable of dissolving more than four times the above quantity of chalk.

[2] *Heilmittellehre*, i. 179.

[3] Wibmer, *Die Wirkung*, &c. ii. 10.

[4] *Elements of Materia Medica*, ii. 82.

[5] *Observations on Ulcers*.

1. **MISTURA CRETÆ**, L. E. D.; *Chalk Mixture; Cretaceous Mixture.* (Prepared Chalk, ℥ss.; Sugar, ʒiij.; Mixture of Acacia, f℥iss.; Cinnamon Water, f℥xviij.: Mix. *L.*—Prepared Chalk, ʒx.; Pure Sugar, ʒv.; Mucilage, f℥iij.; Spirit of Cinnamon, ℥ij.; Water, Oij.: triturate the chalk, sugar, and mucilage together, and then add gradually the water and spirit of cinnamon. *E.* —Prepared Chalk, ℥ss.; Refined Sugar, ʒiij.; Mucilage of Gum Arabic, ℥j.; Water, Oj. [*wine measure*]: Mix. *D.*)—A convenient and agreeable form for the exhibition of chalk. It is in very common use for diarrhœa. Aromatics (as *aromatic confection*), astringents (as *kino* or *catechu*), and narcotics (*opium*), are frequently combined with it. Dose, f℥ss. to f℥ij.

2. **PULVIS CRETÆ COMPOSITUS**, L. E. D.; *Compound Powder of Chalk.* (Prepared Chalk, lbss.; Cinnamon, ℥iv.; Tormentil Root, Acacia Gum, of each, ℥iij.; Long Pepper, ℥ss. *L. D.*—Prepared Chalk, ℥iv.; Cinnamon, in fine powder, ʒiss.; Nutmeg, in fine powder, ʒj.: triturate them well together.) —Aromatic and astringent. Used in diarrhœa. Dose, grs. x. to ℈j.

3. **TROCHISCI CRETÆ**, E.; *Chalk Lozenges.* (Prepared Chalk, ℥iv.; Gum Arabic, ℥j.; Nutmeg, ʒj.; Pure Sugar, ℥vj.: reduce them to powder, and beat them with a little water into a proper mass for making lozenges.)—Mildly antacid and astringent. Used in acidity of stomach and diarrhœa.

4. **CAMPHORATED CRETACEOUS TOOTH-POWDER.** (Precipitated Carbonate of Lime, ℥j.; Camphor, finely pulverized, ʒij.: Mix.)—Extensively used as a dentifrice. On account of its softness it does not injure the enamel: in fact it scarcely possesses the requisite hardness to remove the foreign matters adherent to the teeth. It is objectionable on account of its insolubility, and its accumulation between the gums and the teeth (see *ante*, p. 155). Objections have been made to the use of camphor as a dentifrice, on account of its supposed property of rendering them brittle.[1] Although the validity of the objections is very doubtful, yet, as the camphor serves no useful purpose in the tooth-powder beyond that of a scent, it is advisable to substitute some other odoriferous substance for it.

2. Calcis Bicarbonas. Bicarbonate of Lime.

Formula CaO, 2CO². *Equivalent Weight* 72.

Supercarbonate of lime.—Carbonate of lime dissolves in water by the aid of carbonic acid. It takes up another atom of acid, and forms bicarbonate of lime. If this additional portion of acid be driven off by ebullition, the carbonate of lime which it held in solution is deposited. In this way are formed the incrustations of carbonate of lime on the inner sides of steam boilers, tea-kettles, &c. Caustic alkalies, or lime, also throw down the calcareous carbonate by saturating the excess of acid contained in the bicarbonate. On this is founded Professor Clark's patent process for the purification of common waters, to which allusion has already been made (see *ante*, p. 276). Bicarbonate of lime is a constituent of most spring and river waters. Dupasquier[2] says that it has a very feeble action on soap, and cannot, in the proportions in which it usually exists in ordinary potable waters, decompose it; a conclusion altogether opposed to that at which Professor Clark has arrived. If carbonic acid gas be transmitted through lime water, the liquid is at first rendered turbid by the formation of carbonate of lime; but by continuing the transmission of the gas, the liquor again becomes clear, owing to the conversion of the carbonate into the soluble bicarbonate of lime. If the liquid be charged with a sufficient quantity of carbonic acid, under pressure, it acquires the sparkling and effervescing qualities of soda water and other aërated liquors. Mr. Maugham has taken out a patent for an aërated water of this kind, which he calls *Carrara Water*. It is in fact an effervescing solution of supercarbonate of lime, and is taken like bottled soda-water. It is an objectionable beverage for those persons who are subject to habitual constipation or phosphatic deposits in the urine.

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[1] *Lancet*, vol. ii. 1846, and vol. i. 1847; *Lond. Med. Gaz.* N. S. vol. xiv. 1847.

[2] *Des Eaux de Source et des Eaux de Rivière*, p. 105, 1840.

79. CALCIS TRIPHOSPHAS.—TRIPHOSPHATE OF LIME.

Formula $3CaO,cPO^5$. *Equivalent Weight* 156.

HISTORY.—Six or seven compounds of lime and phosphoric acid have been described: of these the only one employed in medicine or pharmacy is the phosphate found in bones, and which has in consequence been termed *bone-phosphate of lime*. In the year 1768, Gahn discovered that the so-called *earth of bones* consisted chiefly of phosphoric acid and lime; and in 1771, Scheele alluded to the discovery, and in consequence was long supposed to be the author of it. As the calcareous phosphate of bones is subsalt, it is sometimes called *subphosphate of lime*,—a name, however, which is equally applicable to several other phosphates. As it contains the common or tribasic phosphoric acid (see *ante*, p. 334), it is frequently denominated *common* or *tribasic phosphate of lime*. Berzelius termed it the *calcic subphosphate of bones* (*sousphosphate calcique des os*).

NATURAL HISTORY.—This salt occurs in both kingdoms of nature.

a. IN THE INORGANIZED KINGDOM.—Combined with fluoride and chloride of calcium, it occurs in the minerals called *apatite*, *moroxite*, *phosphorite*, and *asparagus stone*. It occurs in most soils, especially in some varieties of chalk, in greater or less abundance, being probably derived, at least in most cases, from the bones of animals (see *ante*, p. 584). It abounds in *oprolites*, (so called from κόπρος, *excrement*, and λίθος, *a stone*) substances supposed to be the excrements of fossil reptiles. It has been found in the deep-well water of the London basin[1] (see *ante*, p. 290.)

β. IN THE ORGANIZED KINGDOM.—It is a constituent of both animals and vegetables. It forms the principal part of the earthy matter of the bones of the *vertebrata* and of the crustaceous envelopes of the *articulata*. According to Dr. Wollaston,[2] it is found in ossified arteries, veins, valves of the heart, bronchiæ, and tendinous portion of the diaphragm, and in the tartar of the teeth.

The calcareous phosphate found in urine, and which is sometimes deposited from this fluid in a pulverulent form, is the neutral phosphate of lime ($2CaO, PO^5$). The phosphate of lime calculus, prostatic calculi, and pineal concretion, also contain, according to Dr. Wollaston, the neutral phosphate.

PREPARATION.—When bones are ignited in close vessels, they yield as a fixed residue *bone black* (see *ante*, p. 312). If, however, they be calcined in open vessels, the whole of the carbonaceous matter is burnt off, and the white product is called *bone ash* (*ossa deusta alba*; *ossa ad albedinem usta*; *ossa calcinata*; *spodium album*) or *bone earth* (*terra ossium*).

A similar product is obtained by calcining the antler (*Cornu*, Ph. L.) of the deer (*Cervus*). In this case the product, when reduced to a fine powder, is called *burnt hartshorn* (*cornu ustum*, E.; *pulvis cornu cervini usti*,

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[1] Berzelius (*Traité de Chimie*, t. iv. p. 72, 1831) states, that the neutral phosphate of lime ($2CaO,PO^5$), held in solution by carbonic acid, is found in many mineral waters.

[2] *Phil. Trans.* for 1797.

D.) Finely-powdered bone ash is, however, usually substituted in the shops for burnt hartshorn.

Bone ash consists principally of *triphosphate of lime*, but mixed with *carbonate* and a small portion of *sulphate of lime*. The sulphate did not pre-exist in the bones; but is formed during calcination by the oxidation of the sulphur contained in the animal matter of the bone.[1] Thomson[2] mentions *magnesia* (not in the state of phosphate) and *chloride of sodium* as constituents of bone earth.

The proportion of phosphate to carbonate of lime in 100 parts of the earthy matter of the bones of the ox and sheep, is as follows:—

	Ox. (Berzelius.)	*Sheep.* (Barros.)
Phosphate of Lime	85·98	80·0
Carbonate of Lime	5·77	19·3

The *Dublin College* gives the following directions for the preparation of *precipitated phosphate of lime* (*calcis phosphas præcipitatum*, D.)

Take of Bones, burnt and reduced to powder, *one part;* Diluted Muriatic Acid, Water, of each, *two parts*. Digest them together during twelve hours, and filter the liquor: add to this, of water of Caustic Ammonia, as much as may be sufficient to throw down the Phosphate of Lime. Let this be washed with a sufficiently large quantity of water, and then dried.

By digestion with hydrochloric acid, the phosphate is dissolved, and the carbonate is decomposed, with the evolution of carbonic acid, and the formation of water and chloride of calcium. On the addition of ammonia, the phosphate is precipitated. It is washed to deprive it of all traces of chloride of calcium and hydrochlorate of ammonia.

PROPERTIES.—Triphosphate of lime is white, tasteless, odourless, insoluble in water, but soluble in nitric, hydrochloric, and acetic acids, from which solutions it is thrown down, unchanged in composition, by ammonia, potash, and their carbonates. When exposed to a very intense heat, it fuses, and undergoes no other change.

Characteristics.—It is known to be a phosphate by its solubility in hydrochloric acid, and its being again thrown down as a white precipitate when the acid solution is supersaturated with caustic ammonia. If it be digested in a mixture of sulphuric acid and alcohol, sulphate of lime is precipitated, and an alcoholic solution of phosphoric acid obtained. The acid may then be recognised by the tests for it already mentioned (see *ante*, p. 335). If the precipitated sulphate of lime be dissolved in water, the solution may be known to contain lime by the tests before described for the calcareous salts (see *ante*, p. 581).

COMPOSITION.—The composition of triphosphate of lime is as follows:—

	Atoms.	*Eq. Wt.*	*Per Cent.*	*Fuchs.*	*Berzelius.*
Lime	3	84	53·84	54·35	51·68
Tribasic Phosphoric Acid	1	72	46·16	45·65	48·32
Tribasic Phosphate of Lime	1	156	100·00	100·00	100·00

According to Berzelius, the phosphate of lime of bones is composed of $8CaO,3PO^5$. But, from the observations of Fuchs and Mitscherlich, it would appear that the amount of lime has been underrated, and that the composition of the bone-phosphate is represented by the more simple formula of $3CaO,PO^5$, which, moreover, harmonizes with the general constitution of the phosphates.

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[1] Dumas, *Traité de Chimie*, t. viii. p. 677, 1846.

[2] *Chemistry of Animal Bodies*, p. 238, 1843.

PHYSIOLOGICAL EFFECTS. *α. On Vegetables.*—In soils, phosphate of lime acts as an important fertilizer, as it supplies an ingredient (phosphoric acid) necessary to the growth of plants. The rapid growth of green confervæ in the deep-well water of the London Basin is ascribed by Professor Graham to the presence of phosphate of lime.

β. On Man and other Animals.—As this salt is a general constituent of the animal structures, especially of the osseous tissues, it, or its components, are essential constituents of our food. Man obtains more of this ingredient than the wants of his system require, from the corn, potatoes, milk, and meat, on which he feeds: the excess is eliminated by the bowels and the various secretions.

Taken medicinally, the effects of this salt are not very obvious. Its topical action is that of an antacid. "As phosphate of lime is very difficultly soluble," observes Wibmer,[1] "it is absorbed in small quantity only, and then acts more or less like lime, as a slight astringent on the tissues and secretions, and increases, incontestibly, the presence of calcareous salts in the bones, the blood, and the urine. Large doses disorder the stomach and digestion by their difficult solubility."

USES.—It has been administered in rickets, with the view of promoting the deposition of bone-earth in the bones. The sesquioxide of iron may be advantageously conjoined with it. Its principal use is in the preparation of phosphorus (see *ante*, p. 329) and phosphate of soda (see *ante*, p. 539). In the arts it is employed for polishing, for the preparation of cupels, &c.

ADMINISTRATION.—Dose from grs. x. to ʒss. For internal use the preparation of the Dublin College is to be preferred, on account of its finer division and consequent more ready solubility in the juices of the alimentary canal.

80. CALCII CHLORIDUM.—CHLORIDE OF CALCIUM.

Formula CaCl. *Equivalent Weight* 55·5.

HISTORY.—This salt, obtained in the decomposition of sal ammoniac by lime, was known, according to Dulk,[2] in the fifteenth century, to the two Hollands, who called it *fixed sal ammoniac* (*sal ammoniacum fixum*). Its composition was not understood until the eighteenth century, when it was ascertained by Bergman, Kirwan, and Wenzel. It is commonly termed *muriate or hydrochlorate of lime* (*calcis murias vel hydrochloras*).

NATURAL HISTORY.—It occurs in both kingdoms of nature.

α. IN THE INORGANIZED KINGDOM.—It is found, in small quantity, in sea and many mineral and well waters.

β. IN THE ORGANIZED KINGDOM.—It has been detected, in a few instances, in vegetables. Thus Pallas recognised it in the root of *Aconitum Lycoctonum.*

PREPARATION.—The following are the methods of preparing it:—

The *London College* orders it to be obtained as follows:—Take of Chalk, ℥v.; Hydrochloric Acid, Distilled Water, of each, Oss. Mix the acid with the water, and to these gradually add the chalk to saturation. Then, the effervescence being finished, strain; evaporate the liquor until the salt is dried. Put this into a crucible, and, having melted it in the fire, pour it out upon a flat clean stone. Lastly, when it is cold, break it into small pieces, and keep it in a well-closed vessel.

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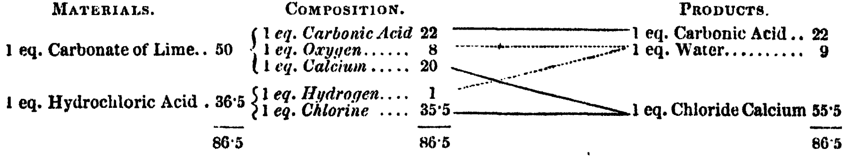
[1] *Die Wirkung*, &c. ii. 9.

[2] *Die Preuss. Pharm. übersetst.* &c. ii. 293, 2te Aufl. Leipsig, 1830.

The *Edinburgh College* orders of White Marble, in fragments, ℥x.; Muriatic Acid (commercial), and Water, of each, Oj. Mix the acid and water; add the marble by degrees; and, when the effervescence is over, add a little marble in fine powder till the liquid no longer reddens litmus. Filter, and concentrate to one-half. Put the remaining fluid in a cold place to crystallize. Preserve the crystals in a well-closed bottle. More crystals will be obtained by concentrating the mother liquor.

In this process one equivalent of hydrochloric acid reacts on one equivalent of carbonate of lime, and produces one equivalent of carbonic acid (which escapes in a gaseous form), one equivalent of water, and one equivalent of chloride of calcium. $CaO,CO^2 + HCl = CaCl + CO^2 + HO$.



MATERIALS.		COMPOSITION.		PRODUCTS.	
1 eq. Carbonate of Lime..	50	1 *eq. Carbonic Acid*	22	1 eq. Carbonic Acid..	22
		1 *eq. Oxygen*......	8	1 eq. Water..........	9
		1 *eq. Calcium*.....	20		
1 eq. Hydrochloric Acid .	36·5	1 *eq. Hydrogen*....	1		
		1 *eq. Chlorine*	35·5	1 eq. Chloride Calcium	55·5
	86·5		86·5		86·5

By heat the crystals of this salt lose their water, and the anhydrous chloride of calcium is obtained.

Chloride of calcium is a secondary product in the manufacture of the hydrated sesquicarbonate of ammonia (see *ante*, p. 437), as well as of solution of ammonia (see *ante*, p. 423); and from this source it is usually procured.

The *Dublin College* orders of the liquor which remains after the distillation of the water of caustic ammonia any requisite quantity. Filter the liquor, and expose it in an open vessel to heat until the muriate of lime becomes perfectly dry. Let it be preserved in a vessel completely closed.

PROPERTIES.—Anhydrous chloride of calcium is a white, translucent solid, of a crystalline texture. Its taste is bitter and acrid saline. It is fusible, but not volatile. It deliquesces in the air, and becomes what has been called *oil of lime* (*oleum calcis*). When put into water, it evolves heat, and readily dissolves in a quarter of its weight of this fluid at 60° F., or in a much less quantity of hot water. By evaporation the solution yields striated crystals (*hydrated chloride of calcium*), having the form of regular six-sided prisms, and which, therefore, belong to the rhombohedric system. These crystals undergo the watery fusion when heated, are deliquescent, readily dissolve in water with the production of great cold, and, when mixed with ice or snow, form a powerful frigorific mixture. Both anhydrous and hydrous chloride of calcium are readily soluble in alcohol.

Characteristics.—This salt is known to be a chloride by the tests for this class of salts before mentioned (see *ante*, p. 369). The nature of its base is ascertained by the tests for calcareous salts (see *ante*, p. 581).

COMPOSITION.—The composition of this salt is as follows:—

	At.	*Eq.Wt.*	*Per Ct.*	*Ure.*
Calcium........	1	20	36·03	36·7
Chlorine	1	35·5	63·97	63·3
Chloride Calcium	1	55·5	100·00	100·0

	At.	*Eq. Wt.*	*Per Ct.*	*Berzelius.*
Chloride Calcium...........	1	55·5	50·7	50·397
Water......................	6	54	49·3	49·603
Crystallized Chloride Calcium	1	109·5	100·0	100·000

PURITY.—Chloride of calcium, when pure, is colourless, evolves no ammonia when mixed with lime, and undergoes no change of colour, nor gives any precipitate with caustic ammonia, chloride of barium, or hydrosulphuric acid.

The fused chloride is free from colour; slightly translucent; hard and friable; totally soluble in water: the solution gives no precipitate on the addition of ammonia or chloride of barium, nor, when diluted with much water, with ferrocyanide of potassium.—*Ph. Lond.*

The crystallized salt is "extremely deliquescent. A solution of 76 grains in one fluidounce of distilled water, precipitated by 49 grains of oxalate of ammonia, remains precipitable by more of the test."—*Ph. Ed.*

PHYSIOLOGICAL EFFECTS. α. *On Animals.*—Three drachms and a half given to a dog caused quick breathing and snorting, with convulsive but vain efforts to vomit, a profuse secretion of saliva, and death in six hours. The mucous membrane of the stomach and small intestines was very blood-shot, and in many places almost black, and converted into a gelatinous mass.[1]

β. *On Man.*—In *small doses* it promotes the secretions of mucus, urine, and perspiration. It operates, therefore, as a liquefacient (see *ante*, p. 175). By continued use it appears to exercise a specific influence over the lymphatic vessels and glands, the activity of which it increases; for under its use glandular and other swellings and indurations have become smaller and softer, and ultimately disappeared altogether. In *larger doses* it excites nausea, vomiting, and sometimes purging; causes tenderness of the præcordium, quickens the pulse, and occasions faintness, weakness, anxiety, trembling, and giddiness. In *excessive doses* the disorder of the nervous system is manifested by failure and trembling of the limbs, giddiness, small contracted pulse, cold sweats, convulsions, paralysis, insensibility, and death.[2] Considered in reference to other medicines, it has the closest resemblance in its operation to chloride of barium. Hufeland[3] says its operation is more irritant than the last mentioned substance, and that its use requires greater caution,—a statement which is directly opposed to the experience of Dr. Wood,[4] and of most other practitioners.

USES.—It has been principally employed in scrofulous affections, especially those attended with glandular enlargements. Beddoes[5] gave it to nearly a hundred patients, and he tells us there are few of the common forms of scrofula in which he has not had successful experience of it. Dr. Wood[6] tried it on an extensive scale, and with decided benefit. It has been found most efficacious in the treatment of tabes mesenterica, on account of its checking purging, diminishing the hectic fever, allaying the inordinate appetite, and, in many cases, ultimately restoring the patient to perfect health. It has also been recommended in chronic arthritic complaints, in bronchocele, in some chronic affections of the brain (as paralysis), and in other cases where the object was to excite the action of the absorbents.

Occasionally, though rarely, it has been employed externally. Thus a bath containing two or three ounces of it, either alone or with chloride of sodium, has been used in scrofula.[7]

In pharmacy fused chloride of calcium is used in the rectification of spirit, on account of its strong affinity for water; and in chemistry it is employed in the drying of gases. In the crystallized state, mixed with half or two-thirds of its weight of ice or snow, it is used for producing an intense degree of cold. Its solution is used as a salt-water bath for chemical purposes.

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[1] Beddoes, *Duncan's Annals of Medicine*, vol. i. Lustr. ii. 208.

[2] Vogt, *Pharmakodynamik*.

[3] Quoted by Wibmer, *Die Wirkung*, &c.

[4] *Edinb. Med. and Surg. Journ.* i. 147.

[5] *Op. cit.*

[6] *Op. cit.*

[7] Vogt, *op. supra cit.*

ADMINISTRATION.—Chloride of calcium is always used medicinally in the form of aqueous solution.

LIQUOR CALCII CHLORIDI, L.; *Calcis Muriatis Solutio*, E.; *Calcis Muriatis Aqua*, D.—*Solution of Chloride of Calcium.* (Chloride of Calcium [fused], ℥iv.; Distilled Water, f℥xij. *L.*—Muriate of Lime [crystals], ℥viij.; Water, f℥xij. *E.*—Muriate of Lime [dry], *two parts*; Distilled Water, *seven parts*, D.—Dissolve and [if necessary] strain). Dose from ♏xl. or ♏l. to fʒij., or gradually increased until nausea is produced. The uses of it have been above noticed.

81. CALCIS HYPOCHLORIS.—HYPOCHLORITE OF LIME.

Formula CaO,ClO. *Equivalent Weight* 71·5.

HISTORY.—In 1798, Mr. Tennant, of Glasgow, took out a patent for the manufacture of a bleaching powder, which in consequence was long known by the name of *Tennant's bleaching powder.* According to the views entertained of its composition it has been successively termed *oxymuriate of lime*, *chloride of lime*, or *chloruret of the oxide of calcium*, and *chlorinated lime* (*calx chlorinata*, Ph. L. and Ed.) It is now usually regarded as a mixture or compound of hypochlorite of lime and chloride of calcium, and its bleaching and disinfecting powers are referred to the hypochlorite or to the hypochlorous acid, which may be regarded as its active principle.

PREPARATION.—Chloride of lime is prepared on a very large scale for the use of bleachers. The *London College*, however, has thought fit to give the following directions for its preparation:—

Take of Hydrate of Lime, lbj.; Chlorine as much as may be sufficient; pass Chlorine to the Lime, spread in a proper vessel, until it is saturated. Chlorine is very readily evolved from Hydrochloric Acid added to Binoxide of Manganese, with a gentle heat (see p. 368).

On the large scale the gas is usually generated in large, nearly spherical, leaden vessels heated by steam. The ingredients employed are binoxide of manganese, chloride of sodium, and diluted sulphuric acid (see *ante*, p. 368). The gas is washed by passing it through water, and is then conveyed by a leaden tube into the combination room, where the slaked lime is placed in shelves or trays, piled over one another to the height of five or six feet, cross bars below each, keeping them about an inch asunder, that the gas may have free room to circulate. The combination room is built of siliceous sandstone, and is furnished with windows, to allow the operator to judge how the impregnation is going on. Four days are usually required, at the ordinary rate of working, for making good marketable chloride of lime.[1] At Mr. Tennant's manufactory at Glasgow, the lime is placed in shallow boxes on the floor of the combination chambers, and is agitated once during the process by iron rakes; the handles of which pass through boxes filled with lime, which serves as a valve.[1] The supply of chlorine is then shut off, and a man enters the chambers and rakes the lime over. The chambers are then closed, and more chlorine introduced, until the lime is saturated.

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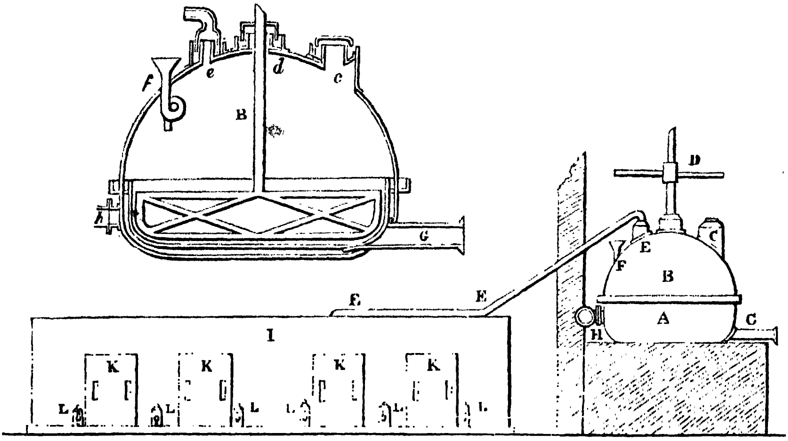
[1] Ure, *Quarterly Journal of Science*, xiii. 1.

At a manufactory in the neighbourhood of London, the chlorine gas is developed in stone jars and conveyed by earthenware tubes to a stone chamber containing the hydrate of lime, which is moved by an agitator.

FIG. 99. FIG. 98.



Apparatus for the Manufacture of Chloride of Lime.

Fig. 98.—A. Iron jacket for heating the retort by steam.
B. Leaden retort for generating chlorine.
C. Aperture for the introduction of manganese and common salt.
D. Arm of the agitator.
E. Gas discharge pipe.
F. Syphon funnel for the introduction of the sulphuric acid.
G. Discharge pipe for drawing off the residuum of the operation.
H. Steam pipe.
I. Combination chamber, divided into four compartments, each having two doors.
K, K. Doors, each having two windows.
L, L. Handles of the rakes passing through boxes.

Fig. 99.—*Section of the Retort.*
B. The agitator. The explanation of the other letters is the same as for fig. 98.

THEORY OF THE PROCESS.—Neither dry caustic lime nor carbonate of lime absorb chlorine gas: hydrate of lime, however, takes it up freely. Chemists are by no means agreed as to the nature of the changes which attend the process.

a. Some regard it as a compound of *chlorine, water,* and *lime.* On this view, when chlorine gas comes into contact with slaked lime, the two substances are supposed to enter into combination.

An objection to this view is, that the odour of chloride of lime is that of hypochlorous acid, and not that of mere chlorine.

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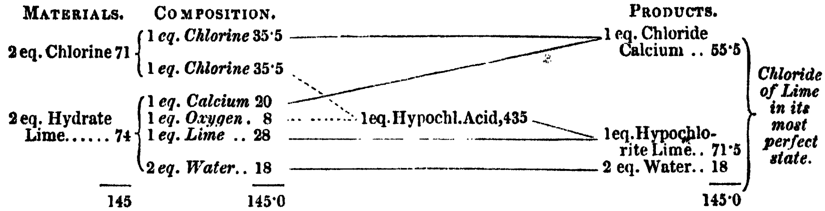
[1] *American Journal of Science,* vol. x. No. 2, Feb. 1826; and Dumas' *Traité de Chimie,* ii. 806.

β. Another view, supported by the discoveries of Balard,[1] and the observations of Gay Lussac,[2] is, that chloride of lime is a mixture or compound of hypochlorite of lime and chloride of calcium. Its formation may, then, be explained as follows:—When chlorine comes into contact with slaked lime, a portion of the latter is decomposed: its base (calcium) combines with chlorine, to form chloride of calcium, while its oxygen unites with another portion of chlorine and forms hypochlorous acid, which combines with some undecomposed lime, to form hypochlorite of lime. $2CaO + 2Cl = CaCl + CaO,ClO$.



The odour of hypochlorous acid which chloride of lime possesses, strongly supports this view. On the other hand, it may be objected, that if chloride of lime contained so large a quantity of chloride of calcium, it would be deliquescent. But to this it may be replied, that the chloride of calcium may be in chemical combination with the hypochlorite of lime.

Properties.—Chloride of lime, as met with in commerce, is a white or brownish-white powder, having a feeble odour of hypochlorous acid, and a strong bitter and acrid taste. Exposed to the air, it attracts carbonic acid, evolves hypochlorous acid, and is thereby converted into a mixture of carbonate of lime and chloride of calcium, the latter of which deliquesces. When heated, it evolves oxygen gas,[3] sometimes also chlorine gas, and becomes converted into a mixture of chloride of calcium and chlorate of lime, which has no bleaching properties. $9CaCl + 9(CaO,ClO) = 12O + 17CaCl + CaO,ClO^5$. Digested in water, the hypochlorite of lime and chloride of calcium, as well as a small portion of caustic lime, dissolve: any carbonate, and the excess of caustic lime, remain undissolved. The solution, which has a slight yellow colour, first reacts on vegetable colours as an alkali, and afterwards bleaches them, especially if an acid be added. Carbonic acid, or a small quantity of sulphuric acid, sets free hypochlorous acid. $CaCl + CaO,ClO + SO^3 = CaCl + CaO,SO^3 + ClO$. But if a large quantity of sulphuric acid be employed, free chlorine is evolved. $CaCl + CaO,ClO + 2SO^3 = 2(CaO,SO^3) + 2Cl$.

Solution of chloride of lime decomposes—at least, when an acid is present—organic colours and putrid substances. The bleaching power on litmus is very slowly evinced unless an acid be present: carbonic acid (as by breathing through the liquid) causes the decolorization to be speedily effected. If air be blown through putrid blood, and then through a solution of chloride of lime, carbonate of lime is precipitated, and the air is disinfected; but if air be first passed through putrid blood, then through caustic potash or milk of lime (to abstract the carbonic acid), and afterwards through the solution of chloride of lime, it retains its stinking quality. The bleaching and disinfecting properties depend, probably, on the oxidizement of the colouring or infectious matter: if an excess of a strong acid be employed in the process, chlorine is evolved, which produces oxygen at the expense of the elements of water: if, on the contrary, no acid be used, Balard[1] supposes that both the hypochlorous acid and lime give out their oxygen, and thereby become chloride of calcium.

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[1] *Researches*, in Taylor's *Scientific Memoirs*, vol. i. p. 269.

[2] *Ann. Chim. et Phys.* 3me sér. t. v. p. 273.

[3] Hence Keller (*Pharmaceutical Journal*, vol. vii. p. 399,) has proposed this as a means of obtaining oxygen gas. Half an ounce of chloride of lime, boiled in two ounces of water, yields 420 cubic centimetres [= about 165 cubic inches] of oxygen gas contaminated with chlorine. The same quantity of chloride and water, with a quarter of an ounce of binoxide of manganese, yielded, on an average, 650 cubic centimetres [= about 256 cubic inches] of oxygen.

The nature of the bleaching process may be illustrated by the action of chlorine and water on indigo. Indigo blue ($C^{16}H^{5}NO^{2}$), water ($2HO$), and chlorine ($2Cl$), yield by their mutual reaction isatine ($C^{16}H^{5}NO^{4}$) and hydrochloric acid ($2HCl$). Isatine and $2Cl$ yield chlorisatine ($C^{16}H^{4}NO^{4}Cl$) and HCl: isatine and $4Cl$ yield bichlorisatine ($C^{16}H^{3}NO^{4}Cl^{2}$) and $2HCl$.

Characteristics.—Its smell and bleaching properties are most characteristic of it. The acids (as sulphuric or hydrochloric) separate chlorine from it. An aqueous solution of it throws down white precipitates with nitrate of silver, the alkaline carbonates, and with oxalic acid or the oxalates. The supernatant liquor from which chloride of silver has been thrown down by nitrate of silver possesses a decolorizing property.

COMPOSITION.—The quantity of chlorine absorbed by slaked lime varies with the pressure, the degree of exposure, and the quantity of water present. Hence the substance sold as chloride of lime is not an uniform product. The following table contains the most important results of Dr. Ure's experiments:—

Prepared with Protohydrate of Lime, without pneumatic pressure. The process was carried on until the Lime ceased to absorb Chlorine.					Commercial Specimens.		
	Synthesis.	*First Analysis.*	*Second Analysis.*	*Mean.*	1.	2.	3.
Chlorine	39·39	40·00	40·62	40·31	23	22	28
Lime..................	46·00	44·74	46·07	45·40	46	78	71
Water	14·60	15·26	13·31	14·28	31		
Chloride of Lime ...	100·00	100·00	100·00	100·00	100	100	100

Good samples of commercial chloride of lime contain, on an average, not more than 36 per cent. of chlorine: and, on the small scale, hydrate of lime cannot be made to absorb more than 40 per cent.

Mr. Brande[2] and Mr. Phillips[3] give the following as the atomic proportions of chlorine and hydrate of lime, in chloride of lime of the best quality:—

	Atoms.	*Eq. Wt.*	*Per Cent.*
Chlorine............	1	35·5	32·42
Hydrate of Lime..	2	74	67·58
Chloride of Lime..	1	109·5	100·00

	Atoms.	*Eq. Wt.*
Bihydrated Chloride of Lime	1	81·5
Lime	1	28
Chloride of Lime (Phillips) .	1	109·5

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[1] *Researches*, in Taylor's *Scientific Memoirs*, vol. i. p. 269.

[2] *Manual of Chemistry*, p. 642, 1848.

[3] *Translation of the Pharmacopœia*, 4th edit. p. 234.

"When water is added to this, the chloride of lime dissolves, leaving nearly all the lime insoluble." (Phillips.)

If, with Berzelius and Balard, we regard bleaching powder as constituted of hypochlorite of lime, chloride of calcium, and water, its composition, corresponding with the proportions assumed by Mr. Brande and Mr. Phillips, will be as follows:—

	At.	*Eq. Wt.*	*Per Ct.*
Hypochlorite of Lime	1	71·5	32·65
Lime	2	56	25·57
Chloride of Calcium	1	55·5	25·34
Water	4	36	16·44
Commercial Bleaching Powder	1	219·0	100·00

or

	At.	*Eq. Wt.*	*Per Ct.*
Trishypochlorite of Lime	1	127·5	58·22
Chloride of Calcium	1	55·5	25·34
Water	4	36·0	16·44
Commercial Bleaching Powder	1	219·0	100·00

When bleaching powder is digested in water, a bleaching liquor is obtained, while a portion of lime remains undissolved. The trishypochlorite is supposed to be decomposed by the action of water, and to deposit two equivalents of lime, while one equivalent of chloride of calcium, and one equivalent of neutral hypochlorite of lime, are dissolved.

If the hydrate of lime be diffused through water, it will then absorb more than its own weight of chlorine, and we form a solution containing 1 equivalent of lime (or of hydrate of lime) and 1 of chlorine, which is the true atomic compound, and is dissolved out of bleaching powder by water (Brande).

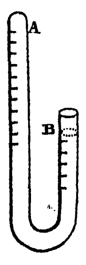
	Atoms.	*Eq. Wt.*	*Per Ct.*
Lime	1	28	38·6
Water	1	9	12·4
Chlorine	1	35·5	49·0
	1	72·5	100·0

or

	Atoms.	*Eq. Wt.*	*Per Ct.*
Hypochlorite of Lime	1	71·5	49·3
Chloride of Calcium	1	55·5	38·3
Water	2	18	12·4
	1	145·0	100·0

Chlorometry.—In order to estimate the bleaching power of the chloride of lime of commerce, various chlorometrical methods have been devised. One method is to determine the quantity of chlorine gas which is given out by a certain weight of chloride on the addition of liquid hydrochloric acid.[1] The liquid may be brought into contact with the chloride placed over mercury, contained in a graduated syphon-tube, closed at one end, (fig. 100, a). When the gas is evolved, the mercury flows out, by the orifice b, into a basin ready to receive it. The resulting film of chloride of calcium protects the surface of the metal from the action of the chlorine. If carbonic acid be suspected, the mercury by agitation absorbs the chlorine, leaving the carbonic acid. Ten grains of bleaching powder yield from three to four cubic inches of chlorine, equivalent to twenty or thirty per cent. by weight.

Fig. 100.



Syphon-tube for chlorometrical purposes.

Another chlorometrical method is to ascertain the bleaching power of the chloride on a standard solution of indigo;[2] but it is not susceptible of accuracy.

A chlorometrical method, which Professor Graham[3] considers "to be entitled to preference," is founded on the fact, that chloride of lime converts sulphate of the protoxide of iron into sulphate of the peroxide. Red ferroprussiate of potash (*ferrosesquicyanide of potassium*) is employed to ascertain the change in the degree of the oxidation of the iron, since it gives a blue precipitate with the protosalts, but not with the persalts of this metal. A quantity of solution of chloride of lime capable of peroxidising 78 grains of sulphate of iron, contains 10 grains of chlorine.

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[1] Ure, *Quarterly Journal of Science*, vol. xiii.

[2] Gay-Lussac, *Ann. of Phil.* xxiv. 218; also in Alcock's *Essay*, before quoted, p. 185.

[3] *Elements of Chemistry*, p. 502.

Gay Lussac has proposed a chlorometrical method founded on the conversion of arsenious into arsenic acid by chlorine. Dissolve 100 grs. of arsenious acid in 2000 of strong hydrochloric acid, and dilute with distilled water till the liquid occupies the volume of 7000 grs. of water (=f℥xvj.) This is the standard test liquor. Diffuse 100 grs. of bleaching powder through 1000 grs. of water, and gently pour over it the test liquor until the liquid acquires the power of bleaching a drop of a solution of sulphate of indigo; that is, until free chlorine is present. The quantity of chlorine in the bleaching powder is equal to the $\frac{1}{100}$th part of the quantity of the test liquor employed. Thus if 3000 grains of the test liquor be employed, the quantity of chlorine in the bleaching powder is 30.

The *Edinburgh College* gives the following characteristics of good chloride of lime:—

> "Pale greyish-white: dry: 50 grains are nearly all soluble in two fluidounces of water, forming a solution of the density of 1027, and of which 100 measures, treated with an excess of oxalic acid, give off much chlorine, and if then boiled and allowed to rest twenty-four hours, yield a precipitate which occupies nineteen measures of the liquid."

The precipitate produced in the solution by oxalic acid is oxalate of lime, and, therefore, this process is one for the detection of lime (or calcium).

The *London College* merely observes that chlorinated lime—

> "Dissolves in dilute hydrochloric acid, emitting chlorine."

Neither College, therefore, gives directions for estimating the real value of chloride of lime.

PHYSIOLOGICAL EFFECTS.—Chloride of lime may be regarded practically as a compound of hypochlorite of lime, chloride of calcium, and hydrate of lime; and its effects are those of the substances now enumerated (see *calx, ante*, p. 581; and *calcis chloridum, ante*, p. 593). The effects for which it is employed in medicine are those of the hypochlorite.

The local action of chloride of lime is that of an irritant and caustic. A solution of it applied to suppurating and mucous surfaces is a powerful desiccant (see *ante*, p. 158), probably in part at least from the uncombined lime in solution. When the secretions are excessive and extremely fetid, it not only diminishes their quantity, but much improves their quality; so that, considered in reference to suppurating and mucous surfaces, it is not only a desiccant, but, in morbid conditions of these parts, a promoter of healthy action. Applied in the form of ointment (composed of a drachm of chloride to an ounce of fatty matter) to scrofulous swellings, Cima[1] found that it provoked suppuration, caused strong redness, promoted the suppurating process, and dispersed the surrounding hardness.

Taken internally, in *small doses* (as from 3 to 6 grains, dissolved in one or two ounces of water), it sometimes causes pain and heat in the stomach, and occasionally, according to Cima, purging. Under the continued use of it, hard and enlarged absorbent glands have become softer and smaller, from which circumstance it has been supposed to exercise a specific influence over, and to promote the healthy action of, the lymphatic system. During its employment, Cima says he did not find it necessary to give purgatives. Dr. Reid[1] gave it in the epidemic fever, which raged in Ireland in 1826, and he tells us that it rendered the tongue cleaner, abated the delirium, and promoted the cutaneous functions. In dysentery it soon put a stop to the bloody evacuations, the umbilical pain, and the tenesmus.

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[1] Configliachi and Brugnatelli's *Giornale di Fisica*, 1825; quoted by Dierbach, *D. neust. Entd. in d. Mat. Med.* 1828, 2te Abt. 597.

I am not acquainted with any facts respecting the effects of chloride of lime *in large or poisonous doses.* Analogy would lead us to expect that it would produce the combined effects of a caustic and of an agent specifically affecting the nervous system.

USES.—The chlorides (hypochlorites) of lime and soda are extensively employed as disinfectants and antiseptics (see *ante,* pp. 162 and 163). I have already stated (see *ante,* p. 371) that chlorine gas stands unrivalled for its power of destroying putrid odours and checking putrefaction, and where uninhabited chambers or buildings are to be purified, fumigations with this gas should be adopted. But its powerful action on the organs of respiration precludes its use in inhabited places; and, in such cases, the alkaline chlorides (chloride of lime, on account of its cheapness) may be substituted. When these substances are in contact with organic matter, it is supposed the hypochlorite gives out oxygen, and is converted into a metallic chloride; the oxygen being the effective disinfecting and antiseptic agent; or it may act by abstracting hydrogen. When, however, the solution of the hypochlorite is exposed to the air, carbonic acid is attracted by the lime, and hypochlorous acid immediately reacts on any organic matter present. Hence these hypochlorites, when exposed to the air, evolve chlorine so slowly, and in such moderate quantities, as not to produce any noxious effects, though their action on organic matters is very powerful. Their most obvious effect is that of destroying the unpleasant odour of putrid matter. Their action on hydrosulphuric acid, ammonia, and hydrosulphate of ammonia (substances evolved by decomposing animal matters) can be readily and easily demonstrated. Other odorous principles given out by putrid matters are, by the experience of most persons, admitted to be destroyed by the alkaline hypochlorites, though Piorry[2] has asserted, they are only overpowered by the stronger smell of chlorine.

The alkaline hypochlorites possess another valuable property—that of stopping or checking the putrefactive process; and hence they are called antiseptics.[3]

These two properties, viz. that of destroying offensive odours and that of preventing putrefaction, render the alkaline hypochlorites most valuable agents to the medical practitioner. We apply them to gangrenous parts, to ulcers of all kinds attended with foul secretions, to compound fractures accompanied with offensive discharges, to the uterus in various diseases of this viscus attended with fetid evacuations: in a word, we apply them in all cases accompanied with offensive and fetid odours. As I have before remarked, with respect to hypochlorite of soda (see *ante*, p. 558), their efficacy is not confined to an action on dead parts, or on the discharges from wounds and ulcers; they are of the greatest benefit to living parts, in which they induce more healthy action, and the consequent secretion of less offensive matters. Furthermore, in the sick chamber, many other occasions present themselves on which the power of the hypochlorites to destroy offensive odours will be found of the highest value: as, to counteract the unpleasant smell of dressings or bandages, of the urine in various diseases of the bladder, of the alvine evacuations, &c. In typhus fever a handkerchief, or piece of calico, dipped in a weak solution of an alkaline hypochlorite, and suspended in the sick chamber, will be often of considerable service both to the patient and the attendants.

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[1] *Trans. of the Associat. of Fellows and Licentiates of the College of Physicians in Ireland,* vol. v. 1828.

[2] *Journ. Chim. Méd.* ii. 601.

[3] For various facts in proof of this, I must refer to the late Mr. Alcock's *Essay on the Use of the Chlorurets,* Lond. 1827.

The power of the hypochlorites to destroy infection or contagion, and to prevent the propagation of epidemic diseases, is less obviously and satisfactorily ascertained than their capability of destroying odour. Various statements have been made by Labarraque and others[1] in order to prove the disinfecting power of the hypochlorites with respect to typhus and other infectious fevers. But, without denying the utility of these agents in destroying bad smells in the sick chamber, and in promoting the recovery of the patient by their influence over the general system, I may observe that I have met with no facts which are satisfactory to my mind as to the chemical powers of the hypochlorites to destroy the infectious matter of fever. Nor am I convinced by the experiments made by Pariset and his colleagues,[2] that these medicines are preservative against the plague. Six individuals clothed themselves with impunity in the garments of men who had died of plague, but which garments had been plunged for six hours in a solution of chloride of soda. But, as Bouillaud[3] has truly observed, the experiments, to be decisive, should have been made with clothing which had already communicated the plague to the wearers of it. Bousquet[4] mixed equal parts of a solution of chloride of soda and the vaccine lymph, and found that the latter still possessed the power of producing the usual cow-pock vesicle. These are a few of the facts which are adverse to the opinion that the alkaline hypochlorites possess the power of preventing the propagation of infectious, contagious, or epidemic diseases. In opposition to them there are but few positive facts to be adduced. Coster[5] found that a solution of hypochlorite of soda destroyed the infectious properties of the syphilitic poison, and of the poison of rabid animals. The statements of Labarraque[6] and others as to the preservative powers of the hypochlorites in typhus, measles, &c. are too loose and general to enable us to attach much value to them.

Considered in reference to medical police, the power of the alkaline hypochlorites to destroy putrid odours and prevent putrefaction is of vast importance. Thus chloride of lime may be employed to prevent the putrefaction of corpses previously to interment, to destroy the odour of exhumed bodies during medico-legal investigations, to destroy bad smells, and prevent putrefaction in dissecting-rooms and workshops in which animal substances are employed (as cat-gut manufactories), to destroy the unpleasant odour from privies, sewers, drains, wells, docks, &c., to disinfect ships, hospitals, prisons, stables, &c. The various modes of applying it will readily suggest themselves. For disinfecting corpses, a sheet should be soaked in a pailful of water containing a pound of chloride, and then wrapped around the body. For destroying the smell of dissecting-rooms, &c. a solution of the chloride may be applied by means of a garden watering-pot. When it is considered desirable to cause the rapid evolution of chlorine gas, hydrochloric acid may be added to chloride of lime.

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[1] Vide Alcock's *Essay*, p. 155 *et seq.*

[2] *Bullet. des Sciences Méd.* xix. 233.

[3] *Dict. de Méd. Prat.* art. *Contagion.*

[4] *Rev. Méd.* Fèv. 1830, p. 264.

[5] Richter, *Ausf. Arzneimittell.* Suppl. Band, 539.

[6] Alcock's *Essay*, pp. 56, 58, &c.

Hypochlorite of lime (or of soda) is the best *antidote* in poisoning by hydrosulphuric acid, hydrosulphuret of ammonia, sulphuret of potassium, and hydrocyanic acid. It decomposes and renders them inert. A solution should be administered by the stomach, and a sponge or handkerchief soaked in the solution, held near the nose, so that the vapour may be inspired. It was by breathing air impregnated with the vapour arising from chloride of lime, that the late Mr. Roberts (the inventor of the miner's improved safety lamp,) was enabled to enter and traverse with safety the sewer of the Bastile, which had not been cleansed for 37 years, and which was impregnated with hydrosulphuric acid.[1] If a person be required to enter a place suspected of containing hydrosulphuric acid, a handkerchief moistened with a solution of chloride of lime should be applied to the mouth and nostrils, so that the inspired air may be purified before it passes into the lungs.

A solution of chloride of lime has been used as a wash in some skin diseases. Derheims[2] used a strong solution with great success in scabies. This mode of curing itch is much cleaner and more agreeable than the ordinary method by sulphur frictions. It has likewise been found successful by Fantonetti[3] in tinea capitis: where the discharge is copious, washes of the chloride may be used with advantage. In burns and scalds, Lisfranc employed lotions of chloride of lime either immediately after the accident, or subsequent to the application of emollient poultices.

Solutions of chloride of lime have been employed with great benefit in ophthalmia. Dr. Varlez, surgeon to the military hospital at Brussels,[4] states that in 400 cases it never disappointed him once. Mr. Guthrie has also reported favourably of it in three cases; as have likewise MM. Colson, Delatte, and Raynaud. The solution used by Dr. Varlez was composed of from a scruple to three or four drachms of chloride, and an ounce of water. It was dropped into the eye, or injected by a syringe, or applied by means of a camel's hair pencil. I have found a weak solution of the chloride successful in the purulent ophthalmia of infants. Gubian[5] proposed to apply a solution of chloride of lime to prevent the pitting from small-pox. The fully maturated pustules are to be opened and washed with a weak solution of this salt: desiccation takes place very promptly, and no marks or pits are said to be left behind.

Chloride of lime may be employed *internally* in the same cases that chloride of soda is administered (see *ante*, p. 557). It has been used with great success by Dr. Reid[1] in the epidemic fever of Ireland. In some of the very worst cases it acted most beneficially, causing warm perspiration, rendering the tongue cleaner and moister, checking diarrhœa, and inducing quiet sleep. I also can bear testimony to the good effects of it in bad cases of fever. In disease of the pulmonary organs, resulting from febrile excitement, Dr. Reid also found it advantageous. In dysentery likewise it was most valuable. He used it by the mouth, and also in the form of clyster. It corrected the intolerable stench of the evacuations, and improved their appearance. Cima[2] used it both internally and externally in scrofula.

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[1] Alcock's *Essay*.
[2] *Journ. de Chim. Méd.* iii. 575.
[3] *Ibid.* ix. 305.
[4] *Med. and Phys. Journ.* Nov. 1827.
[5] *Journ. de Chim. Méd.* vi. 315.

ADMINISTRATION.—*Internally*, chloride of lime may be given in doses of from one grain to five or six grains, dissolved in one or two ounces of water, sweetened with syrup. As the dry chloride of the shops deposits hydrate of lime when put into water, the solution (of the hypochlorite of lime and chloride of calcium) should be filtered, to get rid of this.

ANTIDOTES.—Administer albuminous liquids (as eggs beat up with water) or milk, or flour and water, or oil, or mucilaginous drinks, and excite vomiting; combat the gastro-enteritis by the usual means. Carefully avoid the use of acids, which would cause the evolution of chlorine gas in the stomach.

1. **LOTIO CALCIS CHLORINATÆ**; *Chloride of Lime Lotion.* (Chloride of Lime, ʒj. to ʒiv.; Water, Oj. Triturate and filter).—Applied to foul ulcers and wounds. For the cure of itch, Derheims employed a wash composed of chloride of lime, ℥j., water, Oj.

2. **GARGARISMA CALCIS CHLORINATÆ**; *Chloride of Lime Gargle.* (Chloride of Lime, ʒij.; Water, Oj. Triturate and filter; then add Honey, ℥j.)—Used in ulceration of the mouth and throat.—*A disinfecting mouth-wash* has been before described (see *ante*, pp. 155 and 156).

3. **DENTIFRICIUM CALCIS CHLORINATÆ**; *Chloride of Lime Dentifrice; De-odorizing and Decolorizing Dentifrice.* (Chloride of Lime, ʒj.; Precipitated Chalk, ʒxx. M.)—Used to destroy the unpleasant odour of the breath, and to restore the whiteness of the teeth, especially when stained by tobacco. A drop or two of otto of roses or oil of neroli may be advantageously added to the above.

4. **ENEMA CALCIS CHLORINATÆ**; *Chloride of Lime Clyster.* (Add Chloride of Lime, gr. x. or gr. xv. to a common enema. (See *ante*, p. 554). Employed as a deodorizer when the discharges from the rectum are highly offensive.

5. **UNGUENTUM CALCIS CHLORINATÆ**; *Chloride of Lime Ointment.* (Chloride of Lime, ℈j. to ʒj.; Lard or Butter, ℥j.)—Used by way of friction as an application to scrofulous enlargements of the lymphatic glands.

6. **TROCHISCI CALCIS CHLORINATÆ**; *Chloride of Lime Lozenges.*[3] (Chloride of Lime, ʒss.; Sugar, ℥xx.; Mucilage, q. s.)—For 120 lozenges.

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[1] *Transactions of the King and Queen's College of Physicians in Ireland*, v. 266.

[2] Richter, *Ausf. Arzneimitt.* iv. 305.

[3] *Journ. de Chim. Méd.* t. iii. p. 496.

Order XVI. COMPOUNDS OF MAGNESIUM.

Magnesium, also called *magnium* or *talcium* ($Mg=12$), is the metallic basis of magnesia. It exists both in the inorganised and organised kingdoms, but is more rarely met with than calcium.

82. MAGNESIA.—MAGNESIA.

Formula MgO. *Equivalent Weight* 20.

History.—It was first chemically distinguished from lime in 1755, by Dr. Black, who also shewed the difference between magnesia and its carbonate. From its composition it is sometimes denominated *oxide of magnesium.* In the British pharmacopœias it is simply named *magnesia.* From the mode of procuring it, it is frequently termed *calcined* or *burnt magnesia* (*magnesia calcinata* seu *usta*) ; and is sometimes called *talc earth* (*Talkerde*), or *bitter earth* (*Bittererde*) or the *bittersalt-earth* (*Bittersalzerde*).

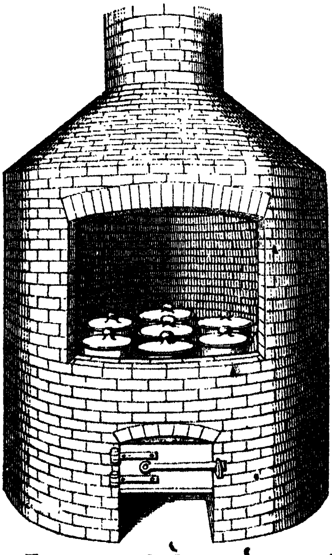
Natural History.—It occurs in both kingdoms of nature.

a. In the Inorganised Kingdom.—Magnesia is found native, in the solid state or in solution, in sea or some mineral waters, in combination with water and various acids (carbonic, sulphuric, boracic, silicic, and nitric). Chloride of magnesium exists in sea water, as also in some springs.

β. In the Organised Kingdom.—Combined with acids it is found in some vegetables (as *Salsola Kali* and *Fucus vesiculosus*), and animals (as in the urine and some urinary calculi of man).

Preparation.—It is prepared by submitting the common carbonate of magnesia to heat, whereby the carbonic acid is driven off.

Fig. 101.



Furnace for the Preparation of Calcined Magnesia.

The *Edinburgh College* gives the following directions for preparing it:—"Take any convenient quantity of Carbonate of Magnesia, expose it in a crucible to a full red heat for two hours, or till the powder, when suspended in water, presents no effervescence on the addition of muriatic acid. Preserve the product in well-closed bottles."

The directions of the *London* and *Dublin Colleges* are essentially the same.

The operation is usually conducted in large, porous, covered crucibles, placed in a furnace expressly devoted to this operation, and heated by coke (see fig. 101).

In this process the hydrated carbonate of magnesia is deprived of its water and carbonic acid, and loses in consequence about 58 per cent. in weight. If the heat be insufficient, or applied for too short a period, only a portion of carbonate is left undecomposed: but if, on the other hand, the heat be raised to whiteness, the preparation is apt to be lumpy. If the carbonate employed contain lime, the flavour of the calcined magnesia is impaired; and if it contain iron, a reddish or foxey tint is communicated to the product. The iron is usually derived from the sulphate employed in the preparation of the magnesian carbonate. It may be got rid of by adding to the solution of the sulphate, a sufficiency of lime water to enable it to restore the blue colour of reddened litmus, and letting it stand for the oxide of iron to subside. Care must of course be taken to prevent soot, cinders, or other impurities, falling into the crucible. After its calcination the magnesia is usually passed through a fine sieve.

To obtain the *heavy calcined magnesia* (*magnesia calcinata ponderosa*) the following formula has been given by Mr. R. Phillips, jun.[1] Dissolve 123 parts of crystallized sulphate of magnesia in boiling water. Dissolve 144 parts of crystallized carbonate of soda in boiling water. Mix the two solutions, and evaporate the mixture to dryness. Calcine the dry residue in a crucible for two hours, or until the whole of the carbonic acid is expelled; then treat the powder which remains with water until the whole of the soluble salt is removed, and dry the residue. The magnesia thus obtained will be much more dense than that prepared by the preceding processes.

PROPERTIES.—It is a light, fine, white, colourless, odourless, and tasteless powder. Its density varies according to the mode of preparing it. Mr. Kirwan says it is 2·3; Richter, 3·07; and Karsten, 3·2. When moistened with water it reacts as an alkali on test papers. It is very slightly soluble in water, and like lime is more soluble in cold than in hot water. Dr. Fyffe states that it requires 5142 parts of cold, and 36000 parts of hot water to dissolve it. Unlike lime it evolves scarcely any heat when mixed with water. By the combined voltaic and oxy-hydrogen flames it has been fused by Mr. Brande.[2] It absorbs carbonic acid slowly from the atmosphere.

Two kinds of calcined magnesia are known and kept in the shops,—one simply called *calcined magnesia*, but which for the sake of distinction I shall call *common calcined magnesia*, and the other distinguished as *heavy calcined magnesia*: to these must be added *Henry's calcined magnesia*, sold as a patent medicine.

1. *Common Calcined Magnesia* (*Magnesia calcinata*). This is a much lighter preparation than the so-called heavy calcined magnesia. All the samples of it which I have met with are contaminated with the carbonate, and effervesce when mixed with water and acetic acid. When moistened and examined by the microscope, in daylight, it appears of a pale yellow colour, and is found to consist of a flocculent or minutely granular substance intermixed with fragments of prismatic crystals (similar in shape to those found in the light carbonate of magnesia presently to be noticed). (See fig. 102.) The crystals are probably carbonate of magnesia which has escaped decomposition during the process of calcination.

2. *Heavy Calcined Magnesia* (*Magnesia calcinata ponderosa*). This is sometimes called *condensed calcined magnesia*. It is a harder, firmer, purer, and heavier preparation than the preceding. None of the commercial samples which I have examined contain so much carbonate as the common calcined magnesia, and do not, therefore, effervesce so freely when mixed with

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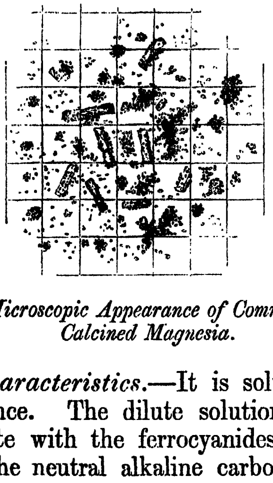
[1] *Pharmaceutical Journal*, vol. iii. p. 480, 1844.

[2] *Manual of Chemistry*.

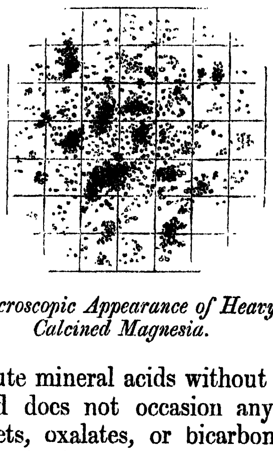
water and acetic acid. Some of the samples which I have met with are, to the naked eye, quite pulverulent; others are composed of little lumps or masses formed by the cohesion of the powder, and which have sufficient hardness to produce a ringing sound when shaken in a glass bottle. On the label of one specimen of this kind which I have met with it is stated that one part in bulk is equal to three parts of the common calcined magnesia. When moistened and examined, in daylight, by the microscope, Howard's heavy calcined magnesia is seen to consist entirely of yellow minute granules more or less cohering into small masses: no fragments of crystals were perceptible in it (see fig. 103). The same I found to be the appearance of other commercial samples of heavy calcined magnesia, as well as of *Henry's calcined magnesia.*

FIG. 102.



Microscopic Appearance of Common Calcined Magnesia.

FIG. 103.



Microscopic Appearance of Heavy Calcined Magnesia.

Characteristics.—It is soluble in the dilute mineral acids without effervescence. The dilute solution thus obtained does not occasion any precipitate with the ferrocyanides, hydrosulphurets, oxalates, or bicarbonates; but the neutral alkaline carbonates, when unmixed with any bicarbonate, throw down a white precipitate (*carbonate of magnesia*); and ammonia with phosphate of soda causes a white precipitate (*ammoniacal-phosphate of magnesia*). Magnesia is insoluble in alkaline solutions, and is thereby distinguished from alumina. Its solution in sulphuric acid is remarkable for its great bitterness.

COMPOSITION.—Magnesia has the following composition:—

	Atoms.	*Eq. Wt.*	*Per Cent.*	*Wollaston.*	*Gay-Lussac.*	*Berzelius.*
Magnesium	1	12	60	59·3	59·5	61·29
Oxygen	1	8	40	40·7	40·5	38·71
Magnesia	1	20	100	100·0	100·0	100·00

PURITY.—When it has been subjected to an insufficient heat during its preparation, or when it has been exposed for some time to the air, it will be found to contain some carbonate of magnesia. Its freedom from carbonate is shewn by its dissolving in dilute mineral acids without effervescence. If the carbonate from which it has been prepared has been insufficiently washed, the calcined magnesia may contain traces of sulphate or hydrochlorate of soda or potash. By boiling it in distilled water, and testing the solution with chloride of barium and nitrate of silver, the absence or presence of sulphuric and hydrochloric acid (or chlorine) may be ascertained. Its hydrochloric solution should occasion no precipitate with the oxalates, bicarbonates, and barytic salts, by which the absence of lime and sulphates may be inferred.

Dissolves in hydrochloric acid without effervescence. Neither bicarbonate of potash nor chloride of barium throws down anything from the solution. It turns turmeric slightly brown. *Ph. Lond.*

"Fifty grains are entirely soluble, without effervescence, in a fluidounce of [pure] muriatic acid: an excess of ammonia occasions in the solution only a scanty precipitate of alumina: the filtered fluid is not precipitated by solution of oxalate of ammonia."

The quantity of hydrochloric acid directed to be used by the Edinburgh College is unnecessarily large.

PHYSIOLOGICAL EFFECTS.—When taken into the stomach, magnesia neutralizes the free acids contained in the stomach and intestines, and forms therewith soluble magnesian salts. In full doses it acts as a laxative; but as it occasions very little serous discharge, Dr. Paris[1] ranks it among purgatives "which urge the bowels to evacuate their contents by an imperceptible action upon the muscular fibres." Part of its laxative effect probably depends on the action of the soluble magnesian salts which it forms by union with the acids of the alimentary canal.

Magnesia exercises an influence over the urine analogous to that of the alkalies: that is, it diminishes the quantity of uric acid in the urine, and when continued for too long a period occasions the deposit of the earthy phosphates in the form of white sand.[2] On account of its greater insolubility, it requires a longer time to produce these effects than the alkalies. When taken in too large quantities and for a long period it has sometimes accumulated in the bowels to an enormous extent, and being concreted by the mucus of the bowels, has created unpleasant effects. A lady took every night during two years and a half, from one to two tea-spoonfuls of Henry's calcined magnesia (in all between 9 and 10 lbs. troy) for a nephritic attack, accompanied with the passage of gravel; subsequently she became sensible of a tenderness in the left side just above the groin, connected with a deep-seated tumor, obscurely to be felt on pressure, and subject to attacks of constipation, with painful spasmodic action of the bowels, tenesmus, and a highly irritable state of stomach. During one of these attacks she evacuated two pints of "sand;" and on another occasion voided soft light brown lumps, which were found to consist entirely of carbonate of magnesia concreted by the mucus of the bowels, in the proportion of 40 per cent. In another case a mass of a similar description, weighing from 4 to 6 lbs., was found imbedded in the head of the colon, six months after the patient had ceased to employ any magnesia.[3]

USES.—As an *antacid* it is as efficacious as the alkalies, while it has an advantage over them in being less irritant and not caustic, and thereby is not apt to occasion disorder of the digestive organs. It may be employed to neutralize acids introduced into the stomach from without, (as in cases of poisoning by the mineral acids) or to prevent the excessive formation of, or to neutralize when formed, acid in the animal economy. Thus it is administered to relieve heartburn arising from, or connected with, the secretion of an abnormal quantity of acid by the stomach; its efficacy is best seen in persons of a gouty or rheumatic diathesis, in which the urine contains excess of uric acid. It often relieves the headache to which such individuals are not unfrequently subject. It is most efficacious in diminishing the quantity of uric acid in the urine, in calculous complaints, and according to Mr. W. T. Brande[1] it is sometimes effectual where the alkalies have failed. It will be found of great value in those urinary affections in which alkaline remedies are indicated, but in which potash and soda have created dyspeptic symptoms. It is a most valuable anti-emetic in cases of sympathetic vomiting, especially that which occurs during pregnancy.[2] It should be given in doses of from a scruple to a drachm in simple water or chicken broth.

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[1] *Pharmacologia*, vol. i. art. *Cathartics.*

[2] W. T. Brande, *Phil. Trans.* 1810, p. 136; and 1813, p. 213.

[3] E. Brande, *Quarterly Journal of Science*, i. 297.

As a *laxative*, magnesia is much employed in the treatment of the diseases of children. It is tasteless, mild in its operation, and antacid,—qualities which render it most valuable as an infant's purgative. Independently of these, Hufeland ascribes to it a specific property of diminishing gastro-intestinal irritation by a directly sedative influence. In flatulency it is combined with some carminative water (dill or anise); in diarrhœa, with rhubarb. It is employed as a purgative by adults in dyspeptic cases—in affections of the rectum, as piles and stricture—and in diarrhœa. It is associated with the carminative waters—with some neutral salts, and sulphate of magnesia, to increase its cathartic operation—or, in diarrhœa, with rhubarb.

Administration.—As a purgative, the dose, for adults, is from a scruple to a drachm; for infants, from two to ten grains. As an antacid, the dose is from ten to thirty grains twice a-day. It may be conveniently given in milk.

83. MAGNESIÆ CARBONATES.—CARBONATES OF MAGNESIA.

Eight compounds of magnesia and carbonic acid have been described: they are as follows:—

			Formulæ.
Subcarbonates	$\frac{2}{3}$ carbonate terhydrated		$3MgO,2CO^2,3HO$
	$\frac{3}{4}$ carbonate (*hydromagnesite*)		$4MgO,3CO^2,4HO$
	$\frac{4}{5}$ carbonate	pentahydrated	$5MgO,4CO^2,5HO$
		hexahydrated (*magnesia alba*)	$5MgO,4CO^2,6HO$
Neutral or *Monocarbonates*	anhydrous (*magnesite*)		MgO,CO^2
	terhydrated		$MgO,CO^2,3HO$
	pentahydrated		$MgO,CO^2,5HO$
Bicarbonate			$MgO,2CO^2$

The formation of several of these compounds appears to be determined by the relative proportions of the precipitants, the temperature of the solutions, and the temperature of desiccation.

Two only of the preceding compounds are employed in medicine—namely, the compound commonly called *carbonate* or *subcarbonate of magnesia*, or *magnesia alba* and the *bicarbonate*.

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[1] *Phil. Trans.* 1813, p. 213.

[2] Dr. Watson, in the *Medical Observations and Inquiries*, 2d edit. vol. iii. p. 335, Lond. 1769.

1. Magnesiæ Subcarbonas Hydrata.—Hydrated Subcarbonate of Magnesia.

Formula $5MgO,4CO^2,6HO$; or $4(MgO,HO,CO^2)+MgO,2HO$. *Equivalent Weight* 242.

HISTORY.—Carbonate of magnesia (*magnesiæ carbonas*, L. E. D.), also called *magnesia alba* and *subcarbonate of magnesia* (*magnesiæ subcarbonas*), was exposed for sale at Rome at the commencement of the 18th century, by Count di Palma, in consequence of which it was termed *Comitissæ Palmæ pulvis*. In 1707, Valentini informed the public how it might be prepared. It is a compound of magnesia, carbonic acid, and water, and, therefore, has been denominated *magnesia hydrico-carbonica* in the Prussian Pharmacopœia, and *carbonas magnesicus cum aquâ* in the French Codex. In the Hamburgh Codex, the terms *magnesia anglica* and *magnesia salis amari* are given as synonymes of this substance.

NATURAL HISTORY.—Native, anhydrous, neutral carbonate of magnesia (MgO,CO^2), called *magnesite*, is found in various parts of Europe, Asia, and America.

The mineral called *hydromagnesite* is, according to L. Gmelin, a quadrohydrate of the ¾ carbonate of magnesia, $4MgO,3CO^2,4HO$; or a compound of hydrate of magnesia and the hydrated carbonate. $MgO,HO+3(MgO,CO^2,HO)$. It accompanies magnesite in India and in America.

Carbonate of magnesia, in conjunction with carbonate of lime, occurs in some mineral waters.

Magnesite constitutes a range of low hills in Hindostan. Some years ago a cargo of it was brought over by Mr. Babington. Dr. Henry[1] analyzed a sample of it, and found its constituents to be *magnesia*, 46; *carbonic acid*, 51; *insoluble matter*, 1·5; *water*, 0·5; and *loss*, 1·=100.

Native carbonate of magnesia, from India, has been imported in considerable quantities into this country; but has been found, as I am informed, unsaleable here. The samples offered for sale in the year 1837 consisted of reniform, opaque, dull masses, adherent to the tongue, having a conchoidal fracture, and considerable hardness. Internally, they were whitish; externally, greyish, or yellowish-white.

The same substance (I presume) was brought over in 1838 in the calcined state, and was offered for sale as *Indian calcined magnesia*. It was nearly white.

PREPARATION.—All the British Colleges give directions for the preparation of carbonate of magnesia.

The *London College* orders of Sulphate of Magnesia, lbiv.; Carbonate of Soda, lbiv. and ℥viij.; Distilled Water, *Cong.* iv. Dissolve separately the carbonate of soda and sulphate of magnesia in two gallons of the water, and strain; then mix, and boil the liquors, stirring constantly with a spatula for a quarter of an hour; lastly, the liquor being poured off, wash the precipitated powder with boiling distilled water, and dry it.

The *Edinburgh College* employs the same proportions of ingredients, and gives similar directions for the preparation of this compound. The precipitate is to be collected on a filter of calico or linen.

The *Dublin College* uses of Sulphate of Magnesia, *twenty-five parts*; Carbonate of Potash, *twenty-four parts*; Boiling Water, *four hundred parts*.

Should the sulphate of magnesia contain iron, it may be got rid of by lime water (see *calcined magnesia*, p. 605).

Two kinds of carbonate of magnesia are known and kept in the shops,—the *light* and the *heavy*.

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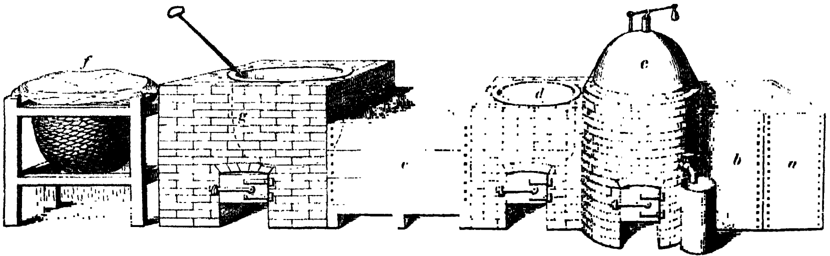
[1] *Annals of Philosophy*, N.S. vol. i. p. 252.

a. Light carbonate of magnesia ; common magnesia.—This is manufactured in the northern parts of this island, and is commonly known as *Scotch magnesia.* It is said to be prepared from the residuary liquor (*bittern*) of sea-water, after the extraction of common salt (see *ante*, p. 550).

The Carbonate of magnesia in squares of English commerce is a light carbonate. According to Durand,[1] lump carbonate of magnesia is thus prepared:—A solution of 100 parts of sulphate of magnesia in 100 of water is put into a vat heated by steam, and a solution of 125 parts of crystallized carbonate of soda is quickly stirred into it, and the temperature raised to 176° to expel carbonic acid, which holds some of the magnesia in solution; the liquor is then decanted off the precipitate, and this is washed three times, by subsidence and decantation, with lukewarm water free from salts of lime; it is then transferred to linen strainers, where it is allowed to drip 24 to 48 hours, and is transferred in a wet state to cubical boxes without bottoms, placed upon a table of plaster or porous stone, so as quickly to absorb the water; after a time, the boxes are turned upside down, so as to present the upper side of the magnesia to the absorptive surface, and the drying is ultimately completed in warm rooms.

β. Heavy carbonate of magnesia ; magnesiæ carbonas ponderosa.—The following is the method which I have seen followed at Apothecaries' Hall, London:—Add one volume of a cold saturated solution of carbonate of soda to a boiling mixture of one volume of a saturated solution of sulphate of magnesia, and three volumes of water. Boil until effervescence has ceased, constantly stirring with a spatula. Then dilute with boiling water, set aside, pour off the supernatant liquor, and wash the precipitate with hot water on a linen cloth: afterwards dry it by heat in an iron pot.

FIG. 104.



Manufactory of Heavy Carbonate of Magnesia.

a. Cistern containing the solution of the Sulphate of Magnesia.
b. Ditto containing solution of Carbonate of Soda.
c. Boiler for supplying hot water.
d. Ditto for the mixed solutions.
e. A back in which the Carbonate of Magnesia is deposited.
f. Filter (linen cloth supported in a basket, contained in a wooden stand).
g. Iron pot for drying the Carbonate of Magnesia.

Mr. Richard Phillips, Jun.[2] gives the following directions for procuring the heavy carbonate of magnesia:—Mix a solution of 123 parts of crystallized sulphate of magnesia with a solution of 144 parts of crystallized carbonate of soda, and boil to dryness. Then treat the residue with water until all the soluble matter (sulphate of soda) is removed, and dry the residual powder.

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[1] Brande, from the *Ann. Chim. et de Phys.* liv. 312.

[2] *Pharmaceutical Journal*, vol. iii. p. 480, 1844.

A heavy carbonate of magnesia has been prepared by Mr. Pattinson, an extensive chemical manufacturer of Gateshead, from the magnesian limestone of Durham.[1] The limestone is calcined in close iron vessels at a dull red heat: by this means the magnesian carbonate only is decomposed, the carbonate of lime requiring a higher temperature for its decomposition. The calcined mass is next placed in a strong, closed iron vessel along with a large quantity of water, and the carbonic acid resulting from the calcination forced into it by a powerful pump in the usual manner. By this means the magnesia only is dissolved, so long as the magnesia is in excess. The saturated solution, containing fifteen grains in the fluid-ounce, is drawn off and boiled down, by which carbonic acid is set free, and a heavy carbonate of magnesia obtained. It has been analyzed by Mr. Fownes,[2] who finds it to be completely free from lime, and to be identical in composition with the common carbonate of magnesia of the shops.

A *heavy* and *gritty carbonate of magnesia* is prepared by separately dissolving twelve parts of sulphate of magnesia and thirteen parts of crystallized carbonate of soda in as small a quantity of water as possible, mixing the hot solutions, and washing the precipitate.

When cold solutions of sulphate of magnesia and carbonate of soda are mixed, and no heat is employed, the product is apt to be gritty; that is, crystalline. According to Professor Graham,[3] carbonate of soda is not so suitable as carbonate of potash for precipitating magnesia, "as a portion of it is apt to go down in combination with the magnesian carbonate; but it may be used provided the quantity applied be less than is required to decompose the whole magnesian salt in solution."

THEORY.—By the mutual reaction of solutions of sulphate of magnesia and carbonate of soda, we ought apparently to obtain, by double decomposition, sulphate of soda and carbonate of magnesia ($MgO,SO^3 + NaO,CO^2 = MgO,CO^2 + NaO,SO^3$).

MATERIALS.		COMPOSITION.		PRODUCTS.	
1 eq. Sulphate Magnesia..	60	1 *eq. Sulphuric Acid*	40	1 eq. Sulphate Soda	71
		1 *eq. Magnesia*	20		
1 eq. Carbonate Soda	53	1 *eq. Soda*	31		
		1 *eq. Carbonic Acid*	22	1 eq. Carbonate Magnesia	42
	113		113		113

It appears, however, that the water decomposes the neutral carbonate of magnesia, and resolves it into a subcarbonate, which is precipitated, and the bicarbonate which remains in solution: by ebullition the latter is decomposed, part of its carbonic acid expelled, and a subcarbonate precipitated.

Three circumstances influence the quality of magnesia alba (hydrated subcarbonate of magnesia), viz. the proportions of the ingredients, the degree of dilution of the solutions, and their temperature. If excess of carbonate of soda be employed, the precipitate, which is dense, retains a portion of this salt: if, on the other hand, excess of sulphate or muriate of magnesia be employed, the product, says L. Gmelin, is light, and contains some sulphuric or hydrochloric acid. The London and Edinburgh College use a very slight excess of sulphate of magnesia. Durand employs a slight excess of carbonate of soda. The more dilute the solutions the lighter the precipitate. At Apothecaries' Hall, strong solutions are employed, and the product is heavy. The effect of ebullition in decomposing the bicarbonate of magnesia has been above explained. The precipitate obtained in the cold is the lightest.

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[1] Mr. Morson, in the *Pharmaceutical Journal*, vol. iii. p. 424, 1844.

[2] *Pharmaceutical Journal*, vol. iii. p. 478, 1844.

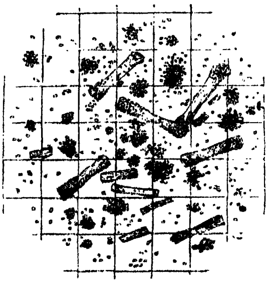
[3] *Elements of Chemistry*, p. 505.

PROPERTIES.—Carbonate of magnesia, as usually met with, is in the form of a white, inodorous, and almost tasteless powder. The *common* or *light* variety occurs in commerce as a very fine light powder, of which 48 grains lightly fill an ounce measure.[1] It is also met with in large rectangular masses with levelled edges, or in smaller cubical cakes (*carbonate of magnesia in squares*). The light powder mixes imperfectly with water. Its taste, in a copious draught, is somewhat disagreeable, owing probably to its having been imperfectly washed. The *heavy* carbonate is, as its name indicates, of greater specific gravity than the light. 160 grains of it lightly fill an ounce measure; so that it would appear to occupy only about ⅓ of the space occupied by the light carbonate. It is tasteless, or nearly so. Both kinds mixed with water have a feebly alkaline reaction on test paper. Carbonate of magnesia is nearly insoluble in water: it readily dissolves in carbonic acid water.

All the specimens of *light* carbonate magnesia (including the magnesia in squares) which I have met with present some traces of crystalline texture when examined by the microscope. They usually consist of an amorphous powder more or less intermixed with slender prisms, which appear as if they were eroded or efflorescent (see fig. 106). These crystals resemble in shape those of the neutral carbonate of magnesia deposited from Dinneford's carbonated magnesia water (see fig. 108, p. 614).

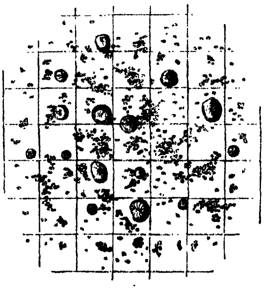
The *heavy* carbonate of magnesia is a granular substance, and contains no traces of the prismatic crystals observed in the light carbonate. When submitted to microscopic investigation it is seen to consist of granules of various sizes: the larger ones are highly refracting, globular, and composed of concentric layers of a radiated structure (see fig. 106). When examined by the polarising microscope, they are found to possess a doubly refracting structure; and like the globules of carbonate of lime deposited from the urine of horses[2] and bullocks,[3] show the black cross (see fig. 107). When placed over a plate of selenite, and examined by polarised light, the quarters or spaces between the arms of the cross are coloured: those next to each other show complementary tints,—the alternate ones, the same tints. Thus, if the first quarter be green, the third will be green also; but the second and fourth will be red.

FIG. 105.



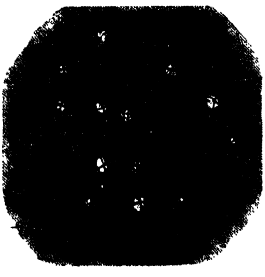
Microscopic Appearance of Light Carbonate of Magnesia.

FIG. 106.



Microscopic Appearance of Heavy Carbonate of Magnesia.

FIG. 107.



Microscopic Appearance of Heavy Carbonate of Magnesia when viewed by Polarized Light.

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[1] West, *Lond. Med. Gaz.* vol. ix. p. 356.
[2] Dr. G. Bird, *Urinary Deposits*, p. 211, 1844.
[3] Mr. A. S. Taylor, *Lond. Med. Gaz.* Sept. 15th, 1848.

Characteristics.—It is distinguished from caustic or calcined magnesia by the effervescence which takes place on the addition of a dilute mineral acid. Its other characteristics are the same as for the latter substance (see *ante*, p. 606).

COMPOSITION.—The following is the composition of carbonate of magnesia of the shops:—

	At.	*Eq. Wt.*	*Per Cent.*	*Phillips.*	*Fownes.* Light of commerce.	*Fownes.* Heavy of commerce.	*Fownes.* Heavy.	*Fownes.* Pattinson's.	*Berzelius.*
Magnesia	5	100	41·3	40·8	42·8	41·2	41·2	41·6	44·75
Carbonic Acid	4	88	36·3	36·0	36·0	36·4	35·6	36·0	35·77
Water	6	54	22·4	23·2	21·2	22·4	23·2	22·4	19·48
Magn. alba, or Magn. Carbonas, Ph. L.	1	242	100·0	100·0	100·0	100·0	100·0	100·0	100·00

Several reasons have led chemists to reject the idea of this compound being an ordinary subsalt.[1]

Mr. Phillips[2] (with whom Mr. Fownes concurs) considers it to be probably a compound of

	Atoms.	*Eq. Wt.*	*Per Cent.*
Bihydrated Magnesia	1	38	15·7
Hydrated Carbonate of Magnesia	4	204	84·3
Carbonate Magnesia, *Ph. L.*	1	242	100·0

PURITY.—Carbonate of magnesia should be perfectly white and tasteless. The water in which it has been boiled should have no alkaline reaction on turmeric paper, nor throw down any thing on the addition of chloride of barium or nitrate of silver; by which the absence of alkaline carbonates, sulphates, and chlorides, is proved. Dissolved in dilute acetic acid, the soluble oxalates and carbonates should occasion no precipitate, by which the non-existence of any calcareous salt is shown.[3]

The water in which it is boiled does not alter the colour of turmeric; chloride of barium or nitrate of silver, added to the water, does not precipitate any thing. One hundred parts dissolved in dilute sulphuric acid lose 36·6 parts in weight. When the effervescence has ceased, bicarbonate of potash does not precipitate any thing from this solution.—*Ph. Lond.*

"When dissolved in an excess of muriatic acid, an excess of ammonia occasions only a scanty precipitate of alumina; and the filtered fluid is not precipitated by oxalate of ammonia."—*Ph. Ed.*

PHYSIOLOGICAL EFFECTS.—The effects of carbonate of magnesia are nearly the same as those of pure magnesia. Its local operation must be somewhat milder than that of the latter, but the difference is hardly perceptible in practice. As the carbonate effervesces with acids, it is more apt to create flatulence when swallowed.

USES.—The uses of the carbonate are the same as those of calcined magnesia; except where the object is to neutralize acid in the alimentary canal (as in cardialgia, and in poisoning by the mineral acids), when the latter preparation is to be preferred on account of its not effervescing with acids, and thereby not causing flatulency. It is employed in the preparation of medicated waters (see *ante*, p. 281).

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[1] Vide Berzelius, *Traité de Chim.* vi. 101.

[2] *Translation of the Pharmacopœia*, 4th edit.

[3] A white light siliceous powder, containing animalcules, was imported a few years ago from New Zealand under the name of magnesia. It contained several species of *gaillionella* and *navicula* (*Pharmaceutical Journal*, vol. v. p. 72, 1846).

ADMINISTRATION.—The dose of carbonate of magnesia as a purgative is from ten grains to a drachm; as an antacid, from five grains to a scruple.

TROCHISCI MAGNESIÆ, E.; *Magnesia Lozenges*. (Carbonate of Magnesia, ℥vj.; Pure Sugar, ℥iij.; Nutmeg, ℈j. Pulverize them, and, with mucilage of Tragacanth, beat them into a proper mass for making lozenges.) —Employed to counteract acidity of stomach.

2. Magnesiæ Bicarbonas.—Bicarbonate of Magnesia.

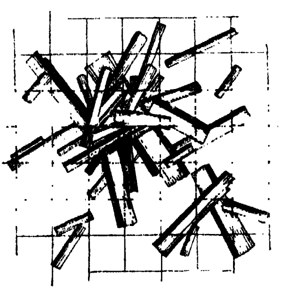
Formula $MgO,2CO^2$. *Equivalent Weight* 64.

This salt has hitherto been obtained in solution only. It is obtained by dissolving the carbonate of magnesia (*magnesia alba*) in water by the aid of carbonic acid. The solution thus obtained is known by various names: such as *aquæ magnesiæ bicarbonatis*, *carbonated magnesia water*, *aërated magnesia water*, *solution of magnesia*, *condensed solution of magnesia*, and *fluid magnesia*. It has a bitterish taste and an alkaline reaction.

The late Mr. Dinneford informed me that he prepared his *fluid magnesia* as follows:—Howard's heavy carbonate of magnesia and distilled water, in the proportion of 17½ grs. of the former to f℥j. of the latter, are introduced into a cylindrical tinned copper vessel, and carbonic acid (generated by the action of sulphuric acid on whiting) is forced into it, by means of steam power, for five hours and a half, during the whole of which time the cylinder is kept revolving. The liquid, which is then perfectly clear and transparent, is drawn off, and preserved in cylindrical zinc canisters, each closed by a cork covered by a lid.

Dry heavy carbonate of magnesia is less readily dissolved than the moist and recently-precipitated carbonate.

FIG. 108.



Crystals of the Hydrated Neutral Carbonate of Magnesia deposited from Dinneford's Solution.

When the solution of bicarbonate of magnesia is exposed for some time to the air, half the carbonic acid escapes, and prismatic crystals of the hydrated neutral carbonate of magnesia are deposited (fig. 108). Their formula, according to Berzelius, is $MgO,CO^2,3HO$; but, according to Dr. Davy,[1] $1\frac{1}{2}\,(MgO,CO^2),4HO$. Fritsche (*Poggend. Ann.* xxxvii. p. 304, 1836,) says that two classes of crystals are deposited: one small and acicular in tufts, and composed of $MgO,CO^2,3HO$; another in tables, and composed of $MgO,CO^2,5HO$.

Sir James Murray's solution is said to contain thirteen grains of carbonate of magnesia to the fluid-ounce.[2]

An extemporaneous solution of bicarbonate of magnesia may be obtained by pouring the ordinary bottle soda-water (carbonic acid water), over some common light carbonate of magnesia contained in a tumbler.

Another mode of preparing it is by dissolving sulphate of magnesia and bicarbonate of soda, or bicarbonate of potash, in water. The relative proportions to be used are one equivalent or 123 parts of crystallized sulphate of magnesia, and one equivalent or 100 parts of bicarbonate of potash, or one equivalent or 84 parts of bicarbonate of soda. The solution contains, besides bicarbonate of magnesia, sulphate of either potash or soda. Some of the commercial solution of magnesia is prepared in this way. In one case Mr. Redwood found that there were only 4 grs. of the hydrated carbonate of magnesia of commerce in f℥j. of the solution, which contained at the same time sulphate of soda and a small quantity of sulphate of potash. By dissolving 14 grs. of crystallized sulphate of magnesia, 7 grs. of bicarbonate of soda, and 2½ grs. of crystallized bicarbonate of potash in an ounce of distilled water, a similar solution might be formed.

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[1] *Lond. and Edinb. Phil. Mag.* vol. xvii. p. 346, 1840.

[2] *Pharmaceutical Journal*, vol. v, p. 507, 1846.

The presence of sulphuric acid in solution may be detected by the chloride of barium (see *ante*, p. 355). If the solution be evaporated to dryness, and calcined for about ten minutes, the residue ought to be pure magnesia, every five grains of which are equal to twelve grains of the hydrated carbonate (*magnesia alba*) of commerce: if it be treated with distilled water any soluble salts present will be dissolved.

Solution of bicarbonate of magnesia is a very agreeable and effective method of administering carbonate of magnesia. It is antacid and mildly laxative. It is employed in dyspepsia, acidity of stomach, and in the uric acid diathesis. Dose fʒss. to f℥iss. thrice or more daily. It may be used in the preparation of effervescing citrate of magnesia (see p. 619).

84. MAGNESIÆ SULPHAS.—SULPHATE OF MAGNESIA.

Formula MgO,SO^3. *Equivalent Weight* 60.

HISTORY.—This salt was originally procured from the Epsom waters by Dr. Grew.[4] It has had a variety of names; such as *Epsom* or the *bitter purging salt*, *sal anglicum*, *sal seidlitzense*, *sal catharticum*, and *vitriolated magnesia*. At the Lymington salt works it is called *physical salt*, to distinguish it from common salt.

NATURAL HISTORY.—It is a constituent of sea and many mineral waters (see *sea water*, p. 293; and *bitter purging waters*, p. 301): it occurs as an efflorescence on other minerals, forming the *hair salt* of mineralogists; and with sulphate of soda and a little chloride of magnesium, constitutes *reussite*.

PREPARATION.—The two great sources of the sulphate of magnesia of English commerce are *dolomite* and *bittern*.

a. **From Dolomite.**—Dolomite, or magnesian limestone, is a mixture or combination of the carbonates of magnesia and lime. It crystallizes in rhombohedrons. It occurs in enormous quantities in various counties of England (as those of Somerset, York, and Nottingham), and is employed for building: York Minster and Westminster Hall are built of it.

Various methods of manufacturing sulphate of magnesia from dolomite have been proposed and practised. One method is to heat this mineral with dilute sulphuric acid: carbonic acid escapes, and a residue composed of sulphate of magnesia and sulphate of lime is obtained. These two salts are separated from each other by crystallization.

In 1816, Dr. William Henry, of Manchester,[2] took out a patent for the following process:—Calcine magnesian limestone so as to expel the carbonic acid; then convert the caustic lime and magnesia into hydrates by moistening them with water. Afterwards add a sufficient quantity of hydrochloric (or nitric or acetic) acid (or chlorine) to dissolve the lime, but not the magnesia, which, after being washed, is converted into sulphate by sulphuric acid (or, where the cost of this is objectionable, by sulphate of iron, which is easily decomposed by magnesia). Or the mixed hydrates of lime and magnesia are to be added to bittern: chloride of calcium is formed in solution, while two portions of magnesia (one from the bittern, the other from the magnesian lime) are left unacted on. Or hydrochlorate of ammonia may be used instead of bittern: by the reaction of this on the hydrated magnesian lime, chloride of calcium and caustic ammonia remain in solution, while magnesia

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[1] *A Treatise of the Nature and Use of the Bitter Purging Salt*, Lond. 1697.

[2] *Repert. of Arts*, vol. xxx. p. 142, 2d Ser.

is left undissolved: the ammonia is separated from the decanted liquor by distillation.

Carbonate of ammonia has also been employed to separate lime from magnesia: carbonate of lime is precipitated, and the magnesia remains in solution, from which it may be easily separated by ebullition.[1]

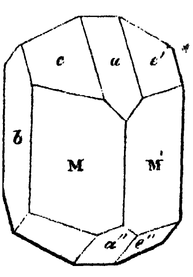
β. **From Bittern.**—*Bittern*, or the *bitter liquor*, is the residual liquor of sea-water, from which common salt (chloride of sodium) has been separated (see *ante*, p. 550). At Lymington, in Hampshire, sulphate of magnesia (or, as it is there called, *physical salt*) is manufactured from bittern during the winter season. The liquor is boiled for some hours in the pans used during the summer for the preparation of common salt. During the ebullition, some common salt is deposited. The lighter impurities are removed by skimming, and the concentrated solution is removed into wooden coolers, where, in 24 hours, one-eighth part of crystals of sulphate, called *single Epsom salts*, or simply *singles*, are deposited. These are drained, dissolved, and re-crystallized: they are then denominated *double Epsom salts*, or simply *doubles*. Four or five tons of sulphate are obtained from brine which has yielded 100 tons of common salt and 1 ton of cat salt (see *ante*, p. 550).[2] No sulphuric acid is employed in the process at Lymington; but if this acid be added to the residual liquor, a further quantity of sulphate may be obtained by the decomposition of the chloride of magnesium.

At Monte della Guardia, near Genoa, sulphate of magnesia is manufactured from schistose minerals, containing sulphur, magnesia, copper, and iron. After being roasted, and moistened to convert them into sulphates, they are lixiviated, and the solution is deprived, first, of copper by refuse iron, and afterwards of iron by lime.[3]

In Bohemia, sulphate of magnesia is procured, by evaporation, from the waters of Seidlitz and Saidschütz. Hermann[4] extracts it from liquids containing chloride of magnesium, by means of sulphate of soda.

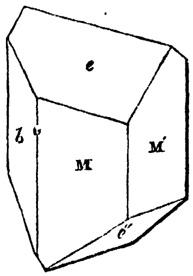
At Baltimore, sulphate of magnesia is procured from the siliceous hydrate of magnesia or *marmolite*, by reducing the mineral to powder, saturating with sulphuric acid, and calcining the dried mass to peroxidize the iron. It is then re-dissolved in water (from which solution the remaining iron is separated by sulphuret of lime), and crystallized. By a second crystallization it is obtained nearly pure.[5]

FIG. 109.



Common Crystal.

FIG. 110.



Crystal with dïedral reversed summits.

PROPERTIES.—The sulphate usually met with in the shops is in small acicular crystals. By solution and re-crystallization, we readily obtain tolerably large four-sided rhombic prisms, with reversed dïedral summits, or four-sided pyramids: the crystals belong to the right prismatic system. Both large and small crystals are colourless, transparent, and odourless, but have an extremely bitter taste. When heated, they undergo the watery fusion, then give out their water of crystallization, become anhydrous, and at a high temperature undergo the igneous fusion, and run into a white enamel, but without suffering decomposition. Exposed to the air, they very slowly and slightly effloresce. They dissolve in their own weight of water at 60°, and in three-fourths of their weight of boiling water. They are insoluble in alcohol.

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[1] *Journal of Science*, iii. 217; vi. 313; ix. 177.

[2] Henry, *Phil. Trans.* for 1810.

[3] Dr. Holland, *Phil. Trans.* 1816, p. 294.

[4] Poggendorff's *Annalen*, xi. 249.

[5] D. B. Smith, in the *Dispensatory of the U. S. of America*.

Characteristics.—Sulphate of magnesia is known to contain sulphuric acid by the tests for the sulphates already mentioned (see *ante*, p. 355). The nature of its base is shown by the tests for magnesia before described (see *ante*, p. 606).

COMPOSITION.—The following is the composition of ordinary crystallized sulphate of magnesia of the shops :—

	Atoms.	*Eq. Wt.*	*Per Cent.*	*Gay-Lussac.*	*Wenzel.*
Magnesia	1	20	16·26	16·04	16·86
Sulphuric Acid	1	40	32·52	32·53	30·64
Water	7	63	51·22	51·43	52·50
Crystallized Sulphate of Magnesia	1	123	100·00	100·00	100·00

PURITY.—The sulphate of magnesia met with in the shops is usually sufficiently pure for all medicinal and pharmaceutical purposes. It should be colourless, and its dilute solution should undergo no change when mixed with ferrocyanides or hydrosulphurets. When obtained from bittern it is sometimes contaminated with chloride of magnesium, which, by its affinity for water, keeps the sulphate in a damp state. By digestion in alcohol the chloride is dissolved; and, by evaporation, the spirituous solution may be obtained in the solid state. It is said that the sulphate of magnesia of the shops is generally adulterated with sulphate of soda.[1] There are several methods of detecting the fraud: the sophisticated salt would effloresce more rapidly than the pure salt, and would communicate a yellow tinge to the flame of alcohol. Boiled with caustic lime and water, all the magnesian sulphate would be decomposed, and the liquor being filtered (to separate the precipitated magnesia and sulphate of lime) would yield, on evaporation, sulphate of soda. If shaken in the cold with carbonate of baryta, a solution of carbonate of soda would be obtained, easily recognised by its alkaline properties. One hundred grains of pure crystallized sulphate of magnesia should yield 16¼ grs. of calcined magnesia.

Very readily dissolved by water. Sulphuric acid dropped into the solution does not expel any hydrochloric acid. 100 grs. dissolved in water, and mixed with a boiling solution of carbonate of soda, yield 34 grains of carbonate of magnesia when dried. *Ph. Lond.*

The evolution of hydrochloric acid gas would be a proof of the presence of a chloride. If less than 34 grs. of carbonate of magnesia be obtained, the presence of sulphate of soda may be suspected.

"Ten grains dissolved in a fluidounce of water, and treated with a solution of carbonate of ammonia, are not entirely precipitated by 280 minims of solution of phosphate of soda." *Ph. Ed.*

PHYSIOLOGICAL EFFECTS.—In moderate doses sulphate of magnesia is a mild and perfectly safe antiphlogistic purgative, which promotes the secretion as well as the peristaltic motion of the alimentary canal. It is very similar in its operation to sulphate of soda, than which it is less likely to nauseate, or otherwise disorder the digestive functions, while it acts somewhat more speedily on the bowels. It does not occasion nausea and griping, like some of the vegetable purgatives, nor has it any tendency to create febrile disorder or inflammatory symptoms; but, on the other hand, has a refrigerant influence: hence it is commonly termed a cooling powder. In small doses, largely diluted with aqueous fluids, it becomes absorbed, and slightly promotes the action of other emunctories: thus, if the skin be kept cool, and moderate exercise be conjoined, it acts as a diuretic. Dr. Christison[1] mentions a case of supposed poisoning, in a boy of ten years old, by two ounces of Epsom salts. The symptoms were staggering, imperceptible pulse, slow and difficult breathing, extreme debility, and death within ten minutes, without vomiting. More recently, an old man, a confirmed drunkard, was poisoned by drinking several pints of beer drugged with sulphate of magnesia. He was seized with violent purging, and died within forty-eight hours. The quantity taken was not ascertained, but there is reason to believe that the dose was large.[2]

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[1] *Pharmaceutical Journal*, vol. iii. p. 481, 1844.

Uses.—On account of the mildness and safety of its operation, its ready solubility, and its cheapness, sulphate of magnesia is by far the most commonly employed purgative, both by the public and the profession.[3] The only objection to its use is its bitter and unpleasant taste. To state all the cases in which it is administered, would be to enumerate nearly the whole catalogue of known diseases. It must, therefore, be sufficient to mention, that it is excellently well adapted as a purgative for febrile and inflammatory diseases, obstinate constipation, ileus, lead colic, even incarcerated hernia, narcotic poisoning, &c. It may be used as an antidote in poisoning by the salts of lead and baryta.

Administration.—As a purgative it is usually administered in doses of from half an ounce to an ounce and a half; but if taken in the morning fasting, a smaller dose will suffice. In delicate females, a drachm, or even less, will usually produce the desired effect. Some carminative or aromatic (as peppermint water or tincture of ginger) is frequently conjoined, to obviate flatulency. In febrile and inflammatory diseases the solution may be acidulated with dilute sulphuric acid with great advantage; or the sulphate may be dissolved in the compound infusion of roses. It is frequently used as an adjunct to the compound infusion of senna, whose purgative effect it promotes, but whose griping tendency it is said to check. In dyspeptic cases, accompanied with constipation, it is conjoined with bitter infusions (as of quassia, gentian, calumba, &c.) As a purgative enema, an ounce or more of it may be added to the ordinary clyster (see *ante*, p. 554).

The *bitter purging saline* waters (see *ante*, p. 301) owe their activity chiefly to sulphate of magnesia.

PULVIS SALINUS COMPOSITUS, E.; *Compound Saline Powder*. (Take of Pure Muriate of Soda, and Sulphate of Magnesia [of each], ℥iv.; Sulphate of Potash, ℥iij. Dry the salts separately with a gentle heat, and pulverize each, then triturate them well together, and preserve the mixture in well-closed vessels).—A mild, cooling, saline aperient. May be employed in habitual constipation. Dose, ʒij. or ʒiij. It may be taken dissolved in half a pint of plain water, or in bottled soda water (carbonic acid water).

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[1] *Treatise on Poisons*, 3d edit. p. 603.

[2] A. S. Taylor, *On Poisons*, p. 3.

[3] Sulphate of magnesia is extensively used in the diseases of cattle. In a letter which I received from the late Mr. Youatt, Veterinary Surgeon to the Zoological Gardens, he says—"For cattle we use the sulphate of magnesia or soda. The former is preferable, on account of its easier solution. I purge the larger elephant, whenever I please, by giving him a drachm of calomel at night, and a pound and a half of Epsom salts in the morning."

85. Magnesiæ Citras.—Citrate of Magnesia.

Formula $3MgO,C^{12}H^{5}O^{11},HO$; or $3MgO,\overline{Ci},HO$. *Equivalent Weight* 234.

Citrate of magnesia may be prepared by saturating a solution of citric acid with either magnesia or its carbonate. Provided the ingredients be pure, 1 equivalent or 201 grs. of crystallized citric acid should saturate 3 equivalents or 60 grs. of calcined magnesia, or 145·2 grs. of the carbonate of magnesia of the shops. I find that ℈j. of the crystallized acid of commerce saturates about 14 grs. of either light or heavy carbonate of magnesia. If a somewhat concentrated solution of the acid be saturated with magnesia, the liquor becomes a hard solid, owing to the union of the salt with the water. Another mode of preparing citrate of magnesia is by double decomposition from sulphate of magnesia and citrate of soda.

Neutral citrate of magnesia is a white, pulverulent, insipid salt, soft to the touch, heavier than magnesia, and, when aided by the addition of a slight excess of the acid, soluble in water. This solution has an acid taste, and is devoid of that unpleasant bitter flavour which usually characterizes the magnesian salts. According to Roge Delabarre,[1] the composition of this crystallized salt is as follows:—

	Atoms.	*Eq. Wt.*	*Per Cent.*
Citric Acid	1	165	50·926
Magnesia	3	60	18·518
Constitutional Water	1	9	2·777
Water of Crystallization	10	90	27·777
Crystallized Citrate of Magnesia	1	324	100·000

Citrate of magnesia is a mild and agreeable aperient. Its superiority over other saline purgatives consists in its being devoid of any unpleasant flavour. Although weight for weight it contains rather more magnesia than the sulphate of magnesia, its operation is milder. The dose of it as a purgative is from ʒviij. to ʒx. for adults.

A solution of this salt in water, acidulated with citric acid and flavoured with syrup of orange peel, forms what has been called *magnesian lemonade*. If taken in the effervescing state it constitutes *effervescing magnesian lemonade.*

Four drachms of crystallized citric acid, and three and a half drachms of the common carbonate of magnesia dissolved in a sufficiency of water, yield rather more than an ounce of solid citrate of magnesia.

1. LIQUOR MAGNESIÆ CITRATIS: *Solution of Citrate of Magnesiæ; Magnesian Lemonade.* Take of Citric Acid, ʒss.; Carbonate of Magnesia, ℈j.; Syrup of Orange Peel, ʒij.; Distilled Water, ℥ij.—These proportions of acid and magnesia are equal to about 44½ grs. of crystallized citrate of magnesia and a slight excess of acid. The carbonate of magnesia dissolves slowly in the solution of citric acid.

2. LIQUOR MAGNESIÆ CITRATIS EFFERVESCENS; *Effervescing Solution of Citrate of Magnesia; Effervescing Magnesian Lemonade.* Take of Citric Acid, ʒss.; Distilled Water, ℥j.; Syrup of Orange Peel, ʒij. Mix.—To be taken with fʒx. of Dinneford's solution of bicarbonate of magnesia in a state of effervescence. This forms a very agreeable effervescing draught.

86. Magnesiæ Tartras. Tartrate of Magnesia.

Formula $2MgO,C^{8}H^{4}O^{10}$, or $2MgO,\overline{T}$. *Equivalent Weight* 172.

Magnesia Tartarica.—Obtained by saturating a solution of tartaric acid with magnesia or its carbonate, and evaporating the solution to dryness in the water bath. The crystals of tartrate of magnesia consist of $2MgO,\overline{T},8HO$. This salt has been used by Rademacher in painful chronic maladies of the spleen —Dose, from ℈j. to ʒj., or more.

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[1] *Pharmaceutical Journal*, vol. vii. p. 17, 1847.

MOXON'S APERIENT EFFERVESCING MAGNESIA contains tartrate of magnesia in an effervescent form, along with tartrate of soda and potash and sulphate of magnesia. It has enjoyed considerable reputation from its peculiar gratefulness to a fastidious stomach, as a remedy in indigestion, heart-burn, nausea, &c. The following is Mr. E. Durand's[1] imitation of it:—Take of Carbonate of Magnesia, one part; Sulphate of Magnesia, Bicarbonate of Soda, Tartrate of Soda and Potash, Tartaric Acid, of each two parts. These ingredients must be perfectly dried by expelling the water of crystallization, then reduced to powder, and finally mixed together. Inclose in dry bottles, with good corks adapted to them, and seal with wax. If there be the least moisture contained in the mixture, carbonic acid will be generated, and bursting of the bottles will follow.—Dose, a tea-spoonful in half a tumbler of water, drunk in a state of effervescence.[2]

ORDER XVII. COMPOUNDS OF ALUMINUM.

Aluminum, Aluminium, or *Alumium,* ($Al=14$) is the metallic basis of the earth alumina.

87. Alumina.—Alumina.

Formula Al^2O^3. *Equivalent Weight* 52.

Oxide of Aluminum; Sesquioxide of Aluminum; Argilla, Argil, or *Clay-earth; Terra aluminosa* or *aluminous earth.* Occurs native as the *sapphire, oriental ruby, oriental topaz,* and *corundum.* Alumina in the free or uncombined state is not used in medicine. In the hydrated form as well as in an impure state (mixed with silica, &c.) it has been employed medicinally.

1. ALUMINÆ HYDRAS. *Hydrate of Alumina.* Obtained by precipitation from alum. Add to a solution of alum an excess of a solution of carbonate of potash: wash the precipitate repeatedly on a filter. In this state it is not absolutely pure, being admixed with a little potash and sulphuric acid; but it is sufficiently pure for medicinal employment, as the small quantity of impurity does not interfere with its therapeutical uses. If it be required quite pure, it should be redissolved in diluted hydrochloric acid, and thrown down again by a solution of caustic ammonia. The precipitate should be collected and washed on a filter, and then pressed and dried between bibulous paper. If the precipitated hydrate be dried at a temperature of between 70° and 80° it contains above 58 per cent. of water, and is an *octohydrate of alumina,* $Al^2O^3,8HO$: if it be dried at 212° it becomes a *terhydrate,* $Al^2O^3,3HO$. Hydrate of alumina is white and tasteless; it is insoluble in water, but is soluble in most acid liquids.

Hydrate of alumina dissolves in the acid gastric liquor, forming aluminous saline solution, which is astringent, and acts mildly as a chemical agent on the animal tissues like alum. In the intestinal canal the aluminous salts, meeting with alkaline juices, suffer decomposition, and are converted into insoluble subsalts; which, according to Mialhe,[3] act chemico-mechanically, and close the excreting pores. Gradually, however, these subsalts are deprived of their acid constituent, and the alumina dissolves in the alkaline liquid. The alkaline aluminate thus formed is perhaps in part rejected from the bowels, and in part absorbed into the blood.

Hydrate of alumina has been employed, as an antacid and astringent, in acidity of stomach, in diarrhœa, dysentery and cholera. Ficinus[4] considered it superior to other absorbents, (as the alkalies, chalk, and magnesia), because the salts which it forms, by union with the acids of the gastric and intestinal juices, are astringent; whereas the others are mostly laxative. It seems well adapted for the vomiting and diarrhœa of infancy, as these maladies are frequently or usually accompanied by preternatural acidity. Seiler,[1] Weese,[2] Neumann,[3] and Durr,[4] have spoken in high terms of its efficacy in those cases.

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[1] *Brit. and For. Med. Rev.* vol. vii. p. 570, 1839.

[2] *American Journal of Pharmacy,* Jan. 1838.

[3] *Traité de l'Art de Formuler,* 1845.

[4] *Zeitschrift f. Natur u. Heilk. d. Dresdener Professoren,* Bd. i. H. i. S. 82 (quoted by Richter, *Ausf. Arzneimittellehre,* Bd. iii. S. 603).

It has also been employed as a topical remedy in catarrhal affections of the conjunctiva.[5]

The dose of it for children is from 3 to 10 grs. A young child should take from ʒss. to ʒj. in 24 hours: older children from ʒj. to ʒij. It should be administered suspended in water, or in an emulsion, by sugar or gum.

2. TERRÆ ALUMINOSÆ.—From the most ancient times various aluminous earths have been employed in medicine. They consist chiefly of silica and alumina usually more or less coloured by iron; their medicinal properties being for the most part due to alumina. They were employed principally as astringents in alvine fluxes. Dale[6] has given a very complete notice of them. He arranges them under two heads, *boles* (*boli*) and *clays* (*argillæ*). The *marls* (*margæ* vel *lutræ*) are intermediate between clay and chalk.

The only substance of this kind now professed to be kept in the shops is *red Armenian bole*, (*bolus armena rubra*) or, as it is commonly called, *bole armeniack.* It is found in Armenia (whence its name), as well as in various parts of Europe. According to Bergmann, it consists of *silica* 47, *alumina* 19, *magnesia* 6·2, *lime* 5·4, *iron* 5·4, and *water* 7·5. But the substance usually sold as red Armenian bole is an artificial mixture prepared by grinding together, in a mill, *pipe clay* and *Venetian red* (red oxide of iron), and afterwards levigating the mixture. Its principal use is as a tooth powder.

Lemnian earth, or the *earth of Lemnos* (*terra Lemnia*) is dug up at Lemnos once a year (on the 15th of August), in the presence of the clergy and magistrates of the island, after the reading of prayers.[7] It is formed into flat cylindrical discs, which are stamped and sold as *sealed earth* or *terra sigillata.* According to Klaproth, it consists of *silica* 66, *alumina* 14·5, *magnesia* 0·25, *lime* 0·25, *natron* 3·5, *oxide* of *iron* 6, and *water* 8·5. Galen went to Lemnos on purpose to examine this earth.

Fuller's earth (*smectis* vel *terra fullonica ;* the *creta cimolia* of Pliny) is dug in Buckinghamshire, Surrey, and Hampshire. According to Klaproth, that obtained at Reigate consists of *silica* 53, *alumina* 10, *magnesia* 1·25, *lime* 0·50, *common salt* 0·10, *potash* a trace, *oxide* of *iron* 9·75, and *water* 24. It is desiccant and astringent. Nurses sometimes apply it to surfaces irritated by acrid discharges, urine, &c.

88. ALUMEN POTASSICUM.—COMMON OR POTASH ALUM.

Formula $KO,SO^3 + Al^2O^3,3SO^3 + 24HO$. *Equivalent Weight* 476.

HISTORY.—Although the term alum (*alumen* of the Romans; *στυπτηρία* of the Greeks) occurs in the writings of Herodotus,[8] Hippocrates,[9] Pliny,[10] Dioscorides,[11] and other ancient writers, yet it is not satisfactorily proved that our alum was the substance referred to. On the contrary, the learned Beckmann[12] has asserted that the alum of the Greeks and Romans was sulphate of iron, and that the invention of our alum was certainly later than the 12th century. But Geber,[1] who is supposed to have lived in the 8th century, was acquainted with alum, and describes the method of burning it; and it is not, I think, improbable that even Pliny[2] was acquainted with it; though he did not distinguish it from sulphate of iron.

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[1] *Zeitschrift f. Natur u. Heilk. d. Dresdener Professoren*, Bd. i. H. i. S. 82 (quoted by Richter, *Ausf. Arzneimittellehre*, Bd. iii. S. 603).

[2] Rust's *Magazin*. Bd. ii. S. 247.

[3] *Bemerkungen über die gebräuchlichsten Arzneimittel.* 1840 (quoted by Dunglison, *New Remedies* Philadelphia, 1843.)

[4] Hufeland's *Journal*, 1835 (quoted by Riecke, *Die neuern Arzneimittel.* 2te Aufl. 1840.)

[5] *Die neuern Arzneimittel und Arzneibereitungsformen*, von Dr. M. Aschenbrenner, 1848.

[6] *Pharmacologia*, 3tia éd. 1737.

[7] Jameson's *Mineralogy*, vol. i. p. 408, 2d edit. 1816.

[8] Lib. ii. (*Euterpe*), cap. 180.

[9] *De Fistulis, De Ulceribus*, &c.

[10] *Hist. Nat.* xxxv.

[11] Lib. v. cap. 123.

[12] *Hist. of Invent.* i. 288.

Common or potash alum is the *alum* (*alumen*, L. E. D.) of commerce and pharmacy. It is also called the *sulphate of alumina and potash* (*sulphas aluminæ et potassæ*, L. E. D.), or the *aluminous sulphate of potash.*

NATURAL HISTORY.—It is found native in the neighbourhood of volcanoes, and constitutes the mineral called *native alum.*

PREPARATION.—The method of preparing alum varies somewhat in different places. The mineral from which (in this country) it is procured is called *aluminous slate*, *aluminous shale*, or *aluminous schist* (*schistus aluminaris*). This substance varies somewhat in its composition in different localities, but always contains sulphuret of iron, alumina, carbon, and sometimes a salt of potash. In the neighbourhood of Glasgow, there are two alum manufactories —one at Hurlet, the other at Campsie. The most extensive alum manufactory in Great Britain is at Hurlet, near Paisley. Here the aluminous schist lies between the stratum of coal and limestone.[3] By the action of the air, it undergoes decomposition, and falls down on the floor of the mine. The sulphur attracts oxygen, and is converted into sulphuric acid, which combines partly with the iron (oxidized by the air), and partly with the alumina. By lixiviation, a solution of the sulphates of iron and alumina is obtained: this is evaporated in large brick cisterns, and when sufficiently concentrated, is run into coolers, where the sulphate of iron crystallizes, and the sulphate of alumina remains in the mother liquors. To these, when heated, sulphate of potash or chloride of potassium is added, by which crystals of alum are obtained: these are purified by a second crystallization. The requisite potash salt is obtained from various sources; as from kelp, or from soap-boilers' liquors. When chloride of potassium is used, it decomposes the sulphate of iron, and yields chloride of iron and sulphate of potash.

Of late years, sulphate of ammonia, obtained from gas liquor, has been employed as a substitute for the sulphate of potash or chloride of potassium. In general, the alum made at Hurlet contains both potash and ammonia.[4]

At Whitby, in Yorkshire, the method of making alum is somewhat different. The schist is piled in heaps, and burnt by means of a slow smothered fire. The calcined ore is lixiviated, and a salt of potash added to the solution after it has deposited sulphates of lime and iron, and earthy matters.[5]

PROPERTIES.—Alum crystallizes usually in regular octohedrons, frequently with truncated edges and angles, and sometimes in cubes. The ordinary alum of the shops consists of large crystalline masses, which do not present any regular geometrical form; but, by immersion in water during a few days, octohedral and rectangular forms are developed on its surfaces.[6] Alum has an astringent and sweetish acid taste: its reaction on vegetable colours is that

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[1] *Search of Perfection*, ch. iii.; and *Invention of Verity*, ch. iv.

[2] For further information, consult Parkes' *Chemical Essays*, i. 625; and Thomson's *History of Chemistry*, i. 125.

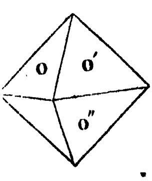
[3] Williams, *Natural History of the Mineral Kingdom*, 2d edit. ii. 315.

[4] Dr. T. Thomson, in *Athenæum* for 1840, p. 771.

[5] Winter, in *Nicholson's Journal*, vol. xxv.

[6] Daniell, *Quarterly Journal*, i. 24.

FIG. 111.



Octohedron of Alum.

of an acid. Its sp. gr. is 1·724. By exposure to the air, it slowly and slightly effloresces. Its transcalent or diathermanous power is very slight (see *ante,* p. 9). When heated, alum undergoes the watery fusion, swells up, gives out its water of crystallization, and becomes a white, spongy mass, called *dried alum.* When submitted to a very strong heat, a portion of the acid is expelled, and escapes, partly as sulphuric acid, partly in the form of oxygen and sulphurous acid, and the residue consists of alumina and sulphate of potash: the acid liquor obtained by heating alum was formerly termed *spirit of alum.* When alum is calcined with charcoal or some carbonaceous substance, as sugar, we obtain a spontaneously-inflammable substance called *Homberg's pyrophorus,* composed of sulphur, potassium, aluminum or alumina, and charcoal.

Alum dissolves in 18 times its weight of cold, and less than its own weight of boiling water.

Under the name of *roch* or *rock alum* (*alumen rupeum*), there is sold in commerce a factitious article consisting of crystalline fragments of alum, not larger than almonds, coloured with Venetian red or Armenian bole. It is an obvious imitation of the red *Roman alum* (*alumen Romanum*), called sometimes *alumen rubrum verum,*[1] to distinguish it from the imitation, which has been denominated *alumen rubrum spurium.*

Matthiolus,[2] who lived for two years in the neighbourhood of the alum mines at Tolfa (a town in the Papal territories and near Civita Vecchia) says that *alumen rupeum,* called by the Italians *alume di rocca,*[3] is made from a very hard stone, of which there are two kinds; one harder than the other and reddish, the other whitish. The alum made from the white stone preserves its whiteness, and is as clear as crystal: the other, on the contrary, is reddish, and has more acrimony. The white is in great request by the silk dyers, as well as by those who dye the finer kinds of wool scarlet.

Thus, then, it appears that there are two kinds of *Roman alum*—one white, the other red; and to both of these the name of *alumen rupeum* or *rock alum* is applied. This explains the fact mentioned by Dale,[4] and some other old pharmacologists, that the term *alumen rupeum* is applied to the common white alum as well as to the red Roman alum. At the present time, however, in English commerce this name is exclusively given to common alum artificially coloured.

The pure crystals of alum-stone consist, according to the analysis of Cordier, of a subsulphate of alumina with sulphate of potash. $KO,SO + 4Al^2O^3,3SO + 8Aq$. Klaproth found 56 per cent., and Vauquelin 24 per cent., of silica in the alum stone of Tolfa. "Alum stone appears to be continually produced at the solfatara near Naples, and other volcanic districts, by the joint action of sulphurous acid and oxygen upon trachyte, a volcanic rock composed almost entirely of felspar" (Graham).

It appears that Roman alum is a different salt to our common alum. Mr. Brande states that "it differs from common alum in crystallizing in opaque cubes, and appears to contain more alumina than common octohedral alum: when this variety is dissolved in cold water and slowly crystallized, it reappears in cubic crystals; but if dissolved in water heated to 110° or higher, a subsulphate of alumina falls, and octohedral alum is obtained. Roman alum has not been accurately analysed."

Characteristics.—That alum is a sulphate is shown by the tests for the soluble sulphates already mentioned (see *ante,* p. 355). It reddens litmus, and forms sulphate of lead when mixed with pure carbonate of lead: in these properties it agrees with the supersulphates. The nature of its basic constituents is shown by the following tests:—The ferrocyanides, the oxalates, and hydrosulphuric acid, occasion no precipitate in a solution of alum. Hydrosulphuret of ammonia, the caustic alkalies and their carbonates, and phosphate of soda, throw down white precipitates: that produced by the alkalies is soluble in an excess of alkali, but is insoluble in solutions of the carbonated alkalies: these characters show the presence of alumina. Potash is recognized in it by perchloric acid and bichloride of platinum. When heated with caustic potash or lime, pure potash-alum evolves no ammonia. Lastly, the crystalline form of the salt assists in recognizing it (see *ante*, p. 463).

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[1] Valentini, *Hist. Simplicium reformata,* Francof. 1716.

[2] *Commentarii in libr. sex P. Dioscoridis,* Venetiis, 1558.

[3] "The most ancient known alum-work is that of Rocca, the present Edessa, in Syria," (Jameson's *Mineralogy,* vol. i. p. 408, 2d edit.)

[4] *Pharmacologia,* 3tia édit. Lond. 1737.

COMPOSITION.—The composition of alum is as follows:—

	At.	*Eq.Wt.*	*Per Ct.*	*Berzel.*	*Thomson.*
Alumina	1	52	10·92	10·76	11·09
Potash	1	48	10·08	9·95	9·86
Sulphuric Acid	4	160	33·68	33·74	32·85
Water	24	216	45·32	45·55	46·20
Cryst^d Pot^h-Alum	1	476	100·00	100·00	100·00

or

	At.	*Eq.Wt.*	*PerCt.*	*Graham.*
Sulphate of Alumina	1	172	36·13	54·11
Sulphate of Potash	1	88	18·48	
Water	24	216	45·39	45·89
Cryst^d Potash-Alum	1	476	100·00	100·00

PURITY.—Alum should be colourless, completely soluble in water (by which the absence of uncombined earthy matter is shown); with a solution of caustic potash or ammonia, should form a colourless precipitate of hydrate of alumina, completely soluble in excess of potash; and should not suffer any change of colour by the addition of tincture of nutgalls or hydrosulphuric acid. The ferro-sulphate of potash, sometimes mixed with alum, cannot be distinguished from the latter by its form, colour, or taste; but is readily detected by potash, which throws down oxide of iron; and by tincture of nutgalls, which communicates a bluish-black colour to it.

It is entirely soluble in water. From the solution, ammonia or potash, when added, throws down alumina free from colour, which again dissolves when the potash is added in excess.—*Ph. L.*

PHYSIOLOGICAL EFFECTS. *a. On Vegetables.*—Alum is probably injurious to plants.[1]

β. On Animals.—Dogs support large doses of alum with impunity. Orfila[2] gave seven drachms of *crystallized* alum in powder to dogs: the animals retained it for from ten to thirty minutes, then vomited, and in an hour or two were apparently well. Two ounces of *burnt* alum in four ounces of cold water occasioned vomiting only. When the œsophagus was tied to prevent vomiting, death took place in five hours, with symptoms of great exhaustion and diminished sensibility. On a post-mortem examination, the mucous membrane of the stomach was found inflamed in the whole of its extent. One ounce of finely-powdered burnt alum applied to the subcutaneous cellular tissue of the thigh, caused excessive suppuration, and death in fifteen hours. Devergie[3] found burnt alum somewhat more active: he says 6½ drachms killed a dog when the œsophagus was tied, and 2 ounces when it was not tied. Moreover, he found burnt alum suspended in cold water more active than when dissolved in warm water. Veterinarians employ it in doses of from one to six drachms for large animals. Bourgelat has seen a phthisical condition induced in horses by the use of alum in too great quantities.[1]

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[1] De Candolle, *Physiol. Végét.* p. 1341.

[2] *Ann. d'Hyg. Publiq. et de Méd. Lég.* i. 235.

[3] *Méd. Légale*, ii. 653.

γ. *On Man.*—Alum acts chemically on the animal tissues and fluids. If a solution of it in water be added, in certain proportions, to albumen, it causes a white precipitate. It also forms insoluble combinations with milk and with gelatine. These phenomena explain the action of alum on the fibrinous, albuminous, and gelatigenous constituents of the living tissues. The compound which alum forms with albumen is soluble in acetic and in hydrochloric acid, and the alumina is precipitable from these solutions neither by ammonia nor by potash.[2] Mialhe, as I have before explained (see *ante*, p. 620), accounts for the astringent effects of alum by the precipitation of a sub-salt, by the alkali of the animal fluids; but his notion, that when an excess of alum is used, this sub-salt is dissolved, and a liquefacient effect produced by the saturation of all the albuminous liquids of the animal economy with alum, appears to be untenable.

The immediate topical effect of a solution of alum is that of an astringent —namely, corrugation of fibres and contraction of small vessels, by virtue of which it checks or temporarily stops exhalation and secretion, and produces paleness of parts by diminishing the diameters of the small blood-vessels. It is by these local effects that alum, when taken internally, causes dryness of the mouth and throat, somewhat increases thirst, checks the secretions of the alimentary canal, and thereby diminishes the frequency and increases the consistency of the stools, as observed by Wibmer[3] in his experiments made on himself with alum in doses of three grains dissolved in five drachms of water, and taken several times during the day.

But when alum is applied to a part in larger quantities, and for a longer period, the astriction is soon followed by irritation, and the paleness by preternatural redness. And thus taken internally in large doses, alum excites nausea, vomiting, griping, purging, and even an inflammatory condition of the intestinal canal—effects which may be perhaps induced by small quantities in persons endowed with unusual or morbid sensibility of the stomach and bowels, as in the case of the lady in whom dangerous gastro-enteritis was apparently induced by a single dose of a solution containing between ten and twenty grains of burnt alum.[4] Ordinarily, however, tolerably large doses of alum may be given without any unpleasant effects. Thus Professor Dumeril has given a drachm, properly diluted, in chronic diarrhœas within twenty-four hours; Professor Marc, two drachms in passive hemorrhages within the same period of time; and MM. Kapeler and Gendrin have administered three drachms at one dose in colica pictonum.[5]

Alum becomes absorbed. Orfila[6] detected alumina in the liver, spleen, and urine of animals to whom alum had been administered.

After its absorption, alum appears to act as an astringent or astringent-tonic on the system generally, and to produce more or less general astriction of the tissues and fibres, and a diminution of secretion. Such at least appear to be its effects in some passive hemorrhages and mucous discharges. Barbier[1] says alum "irritates the lungs, and often produces cough," but I am not aware of any other practitioner having confirmed this statement. Kraus[2] observes, that the urine becomes remarkably acid from the use of alum.

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[1] Moiroud, *Pharm. Vétér.* 225.
[2] C. G. Mitscherlich, *Lehrbuch d. Arzneimittellehre.*
[3] *Die Wirkung*, &c. i. 114.
[4] *Ann. d'Hyg. Publique et de Méd. Lég.* i.
[5] Devergie, *Méd. Lég.* ii. 656.
[6] *Toxicologie*, 4ème éd. t. i. pp. 301 and 302, 1843.

Uses.—Alum is employed both as an external or topical, and as an internal remedy.

α. As a topical remedy.—Solutions of alum are sometimes employed *to produce contraction or corrugation of the tissues,* and thereby to prevent displacement of parts, especially when accompanied with excessive secretion. Thus it is used as a gargle in relaxation of the uvula with evident advantage. In the early stage of prolapsus of the rectum, a solution of alum, applied as a wash, is sometimes of service, especially when the disease occurs in infants. Washes or injections containing alum are of occasional benefit in prolapsus of the uterus.

In hemorrhages, whether proceeding from an exhalation or exudation from the extremities or pores of the minute vessels, or from the rupture of a blood-vessel, a solution, or, in some cases, the powder of alum, may be used with advantage as a *styptic,* to constringe the capillary vessels, and close their bleeding orifices. Thus in epistaxis, when it is considered advisable to arrest the hemorrhage, assistance may be gained by the injection of alum into the nostrils, or by the introduction of lint moistened with the solution. Where this fails to give relief, finely-powdered alum may be employed in the manner of snuff. In hemorrhage from the mouth or throat, gargles containing alum are useful. In hæmatemesis, as well as in intestinal hemorrhage, alum whey may be administered; though, of course, no reliance can be placed on it, as the hemorrhage usually depends on circumstances which astringents merely cannot be expected to obviate. In uterine hemorrhage, a sponge soaked in a solution of alum may be introduced into the vagina with good effect. To check the hemorrhoidal flux when immoderate, washes or enemata containing alum may be employed. To stop the bleeding after leech-bites in children, a saturated solution, or the powder of alum, may be applied to the punctures.

In certain inflammations, alum has been used as a *repellent* (see *ante,* p. 159); that is, it has been applied to the inflamed part in order to produce contraction of the distended vessels, and thereby to diminish the quantity of blood in the seat of the disease in a manner almost mechanical. Thus in the first stage of ophthalmia it is sometimes considered expedient to cut short the disease by the application of a strong astringent solution (as a saturated solution of alum or of acetate of lead). "It is not to be denied," observes Dr. Jacob,[3] "that such applications may have the effect of arresting the progress of the disease at once; but if they have not that effect, they are liable to produce an increase of irritation." But, as the details necessary for making the student acquainted with all the circumstances respecting the use of stimulating or astringent applications in the first stage of ophthalmia are too lengthened and numerous to admit of their proper discussion in this work, I must refer for further particulars to the essay of Dr. Jacob before quoted, as well as to the treatises of writers on ophthalmic surgery. I may, however, add, that whatever difference of opinion exists as to the propriety of these applications in the first stage of ophthalmia, all are agreed as to their value after the violence of vascular action has been subdued. In the treatment of the purulent ophthalmia of infants, no remedy is perhaps equal to an alum wash.

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[1] *Traité Elément. de Mat. Méd.* 2d edit. i. 440.

[2] *Heilmittellehre,* 255.

[3] *Cyclopædia of Practical Medicine,* art. *Ophthalmia.*

In angina membranacea, called by Brétonneau[1] diphtheritis, great importance has been attached to the employment of local applications. Of these, hydrochloric acid, calomel, and alum, have, in succession, been highly praised by this writer. In order to promote the expulsion of the false membrane, he recommends the insufflation of finely-powdered alum. This is effected by placing a drachm of it in a tube, and blowing it into the throat.[2] Velpeau has subsequently confirmed the statements of Bretonneau, and extended the use of alum to other inflammatory affections of the throat, as those arising in scarlatina, small-pox, &c. In these cases powdered alum may be applied to the affected parts by means of the index finger. Gargles containing this salt will be found useful in most kinds of sore-throat, ulcerations of the mouth and gums, aphthæ, &c. In inflammation of the uvula, accompanied with membraniform exudation, alum washes are serviceable both in children and adults.[3]

Alum has been employed as an *astringent*, to diminish or stop excessive secretion from the mucous surfaces. Thus a weak solution of this salt is used to repress the discharge in the latter stages of conjunctival inflammation; to check profuse ptyalism, whether from the use of mercury or other causes; and to remove gleet or leucorrhœa. In old-standing diarrhœas, it has been administered, in combination with the vegetable astringents (kino, for example), with occasional advantage. It is also applied to check profuse secretion from ulcers.

β. *As an internal remedy.*—Alum has been employed, in conjunction with nutmeg, as a remedy for intermittents. Given just before the expected paroxysm, it has, in some cases, prevented it.[4]

In the treatment of *lead colic*, alum has been found more successful than any other agent or class of remedies. It was first used in this disease by a Dutch physician, named Grashuis,[5] and was afterwards administered in fifteen cases by Dr. Percival[6] with great success. Its efficacy has been fully established by Kapeler (physician to the Hôpital St.-Antoine, in Paris) and Gendrin,[7] and by Dr. Copland,[8] as well as by several other distinguished authorities. It allays vomiting, abates flatulence, mitigates pain, and opens the bowels more certainly than any other medicine, and frequently when other powerful remedies have failed. It should be given in full doses (as from a scruple to two drachms), dissolved in some demulcent liquid (as gum-water) every three or four hours. Opium and (according to Dr. Copland) camphor may be advantageously conjoined. Kapeler also employs oleaginous enemata. The modus operandi of alum in lead colic is not very clear. The benefit has been ascribed by some to the chemical action of the sulphuric acid on the lead contained in the intestines; and in support of this view must be mentioned the fact, that other sulphates (as those of magnesia, soda, zinc, and copper), as well as free sulphuric acid, have been successfully employed in lead colic. But, on the other hand, the presence of lead in the primæ viæ or evacuations, and, consequently, the formation of sulphate of lead in saturnine colic, have not been demonstrated; though the experiments of Dr. C. G. Mitscherlich[1] have shown that, when the acetate of lead is swallowed, the greater part of it forms an insoluble combination with the gastro-intestinal mucus, and in this state may remain some time in the alimentary canal. Moreover, alum has been found successful by Kopp[2] in other varieties of colic not caused by lead, and unaccompanied by constipation. Dr. Copland is disposed to ascribe the benefit of alum and other sulphates in lead colic to their "exciting the action of the partially-paralyzed muscular coat of the bowels, and thereby enabling them to expel retained matters of a morbid or noxious description"—an explanation which is inconsistent with the observation of Kopp just quoted.

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[1] *Rech. sur l'Inflam. spéc. du Tissu Muqueux*, 1826.

[2] See also Trousseau and Pidoux, *Traité de Thérap.* ii. 291.

[3] Trousseau and Pidoux, *op. cit.*

[4] Cullen, *Materia Medica.*

[5] *De Colica Pictonum*, Amst. 1752, et *Append.* 1755.

[6] *Essays, Med. and Exper.* ii. 194.

[7] Quoted by Trousseau and Pidoux, *op. cit.*

[8] *Dict. of Med.* i. 374.

Alum is administered internally in several other diseases, of which a brief notice only can be given. In passive or asthenic hemorrhages from distant organs; as hæmoptysis, menorrhagia and other uterine hemorrhages, hæmaturia, &c. In colliquative sweating, diabetes, gleet, gonorrhœa, and leucorrhœa. In the three latter diseases it may be combined with cubebs. Kreysig[3] has advised its use in dilatation of the heart and aortic aneurism. More recently, Dzondi[4] has also recommended it in these diseases; and Sundelin[5] has mentioned a case of supposed dilatation of the heart, in which relief was gained by the use of alum. In chronic diarrhœa, alum is occasionally serviceable.

ADMINISTRATION.—The dose of alum is from ten grains to one or two scruples. It may be taken in the form of powder, or made into pills with some tonic extract, or in solution. To prevent nausea, an aromatic (as nutmeg) should be conjoined. A pleasant mode of exhibition is in the form of *alum whey* (*serum aluminosum*, seu *serum lactis aluminatum*), prepared by boiling two drachms of powdered alum with a pint of milk, then straining: the dose is a wine-glassful. The *saccharum aluminatum* of the Prussian Pharmacopœia is composed of equal parts of white sugar and alum: it may be given to children as well as adults. In prescribing alum, it is to be remembered that the vegetable astringents decompose it; by which the astringent property of the mixture is probably diminished.

For topical uses, alum is used in the form of powder, solution, and poultice. Powder of crystallized alum is applied to the mouth and throat as before mentioned. Solutions of alum are made, for topical purposes, of various strengths, according to the object in view.

ANTIDOTE.—In a case of poisoning by alum, let the contents of the stomach be immediately evacuated. Promote vomiting by the use of tepid diluents. The inflammatory symptoms are to be combated by the usual antiphlogistic means. Magnesia has been employed, but is said by Devergie to be altogether useless.

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[1] *Müller's Archiv.* No. V. 353, 1836, quoted in *Brit. Ann. of Med.* vol. i. 204, 1837.

[2] *Denkwurdigkeit*, i. 342, quoted by G. A. Richter, *Ausführ. Arzneim.* Suppl. Bd. 515.

[3] *Die Krankh. d. Herzens*, Bd. ii. Abt. 2, S. 714, in Richter, *op. cit.*

[4] *Aeskulap.* Bd. 1, St. 1, 1821, in Richter.

[5] *Heilmittellehre*, ii. 278.

1. **ALUMEN EXSICCATUM**, L. E.; *Alumen siccatum*, D.; *Dried Alum; Alumen ustum; Burnt Alum.* (Let Alum liquefy in an [iron or] earthen vessel over the fire; then let the fire be increased until the ebullition has ceased [and vapour is no longer discharged], *L.*—The directions of the *Edinburgh* and *Dublin Colleges* are essentially the same; except that they order the dried alum to be reduced to powder.)—In the preparation of this substance, care must be taken not to apply too great a heat, lest a portion of the acid be driven off as well as the water. On this account, a shallow earthen vessel is preferable to a crucible. Dried alum has a more astringent taste, and does not dissolve so readily in water as the crystallized salt. It is employed as a mild escharotic to destroy exuberant spongy granulations; as those commonly known under the name of proud flesh.

2. **LIQUOR ALUMINIS COMPOSITUS**, L.; *Compound Solution of Alum; Aqua Aluminosa Bateana*, or *Bates's Alum Water.* (Alum, Sulphate of Zinc, each ℥j.; Boiling Water, Oiij. Dissolve the Alum and Sulphate of Zinc together in the Water; afterwards strain.)—This solution is used as a detergent and astringent wash in old ulcers; when diluted, as a collyrium in mild conjunctival inflammation, as an injection in gleet and leucorrhœa, and as an application to chilblains and slight excoriations.

3. **PULVIS ALUMINIS COMPOSITUS**, E.; *Compound Powder of Alum.* (Alum, ℥iv.; Kino, ℥j. Mix them, and reduce them to fine powder.)—Astringent. Employed in hemorrhages from the stomach, bowels, and uterus; in old diarrhœas; and as an application to flabby indolent ulcers.

4. **CATAPLASMA ALUMINIS**, D.; *Cataplasm of Alum; Alum Poultice; Albumen Aluminosum.* (Whites of two Eggs; Alum, ʒj. Shake them together to make a coagulum.)—"In cases of chronic and purulent ophthalmia, it is applied to the eye between two folds of old linen. It has been praised as a good application to chilblains which are not broken."[1] "Another kind of alum poultice in use is made by coagulating milk with alum, and using the curd as a poultice."

89. Aluminæ Acetas.—Acetate of Alumina.

Formula $Al^2O^3,3C^4H^3O^3$; or $Al^2O^3,3\bar{A}$. *Equivalent Weight* 205.

Argilla Acetica.—Obtained by digesting hydrate of alumina in strong acetic acid until the acid is saturated. If heat be applied, it occasions the precipitation of a subsalt of alumina. For pharmaceutical purposes, the solution is sometimes directed to be evaporated by a gentle heat to a gelatinous consistence.[2] The solution of acetate of alumina has a styptic, somewhat sweetish taste; and, by spontaneous evaporation, yields long, transparent crystals. By exposure to a very gentle heat, these become pulverulent, and in this state consist[3] of $Al^2O^3,3\bar{A},3HO$.—An impure solution of acetate of alumina may be obtained by mixing a solution of alum with one of sugar of lead: sulphate of lead precipitates, and the acetate of alumina remains in solution mixed with either sulphate or acetate of potash. If 476 grs. of alum be decomposed by 760 grs. of crystallized acetate of lead, the acetates of alumina and potash are left in solution; but if 476 grains of alum be decomposed by only 570 grs. of crystallized acetate of lead, the acetate of alumina and sulphate of potash are left in solution.—Acetate of alumina possesses astringent and antiseptic properties. It has been used in hæmoptysis, diarrhœa, and gonorrhœa: in the latter complaint it has been both administered internally and applied as an injection. Gannal[1] has employed it as a preservative of dead animal matter. To preserve bodies, he injects five or six pints of a solution of acetate of alumina by the carotid artery. In this way all parts (except the brain) may be preserved for years. The parts thus prepared evolve the odour of acetic acid, and corrode the scalpels.[2]—Dose from ℨss. to ℨj. daily in a mucilaginous decoction; for injections, from gr. x. to gr. xv. in three fluidounces of distilled water.

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[1] Montgomery's *Observations on the Dublin Pharmacopœia.*

[2] Geiger, *Pharmacopœia Universalis.*

[3] Thomson, *An Attempt to establish the First Principles of Chemistry*, vol. ii. p. 315, 1825.

ORDER XVIII. COMPOUNDS OF CHROMIUM.

Some few of the compounds of the metal *Chromium* (Cr=28) have been employed in medicine; and on this account, as well as from the circumstance that occasionally they have been taken as poisons, a short notice of some of them appears desirable.

90. Acidum Chromicum.—Chromic Acid.

Formula CrO^3. *Equivalent Weight* 52.

Peroxide of Chromium.—The readiest mode of obtaining it is as follows:—Add 1½ measures of concentrated oil of vitriol (free from lead) to 1 measure of a cold saturated solution of bichromate of potash. Dark crimson needles of chromic acid are deposited: decant the liquid, and place the crystals on a thick, flat tile of biscuit porcelain; compress for a considerable time the crystals by another tile placed over them. On removing the chromic acid, it will be found dry.[3] According to Schröffer,[4] acid thus obtained contains 6 or 7 per cent. of potash, and 0·7 of sulphuric acid. For medicinal purposes, however, this impurity is unimportant.—Chromic acid occurs in ruby red, prismatic, deliquescent crystals, whose taste is sour, acrid, and metallic. It is soluble in water, but the solution is decomposed by solar light, and deposits the oxide of chromium. It dissolves also in alcohol, and from this solution the green oxide is slowly deposited. It is a powerful oxidizing and bleaching agent, especially for organic substances, yielding half its oxygen and passing to the state of the green sesquioxide. $2CrO^3=Cr^2O^3+O^3$. It stains the skin yellow, and the stain can be removed by an alkali only. Its action on the living surface is that of a chemical irritant. If there exist the slightest abrasure, it causes painful wounds. The troublesome sores produced on the hands and arms of dyers who use the bichromate of potash, are ascribed by Ducatel[5] to the action of the free chromic acid. If swallowed, the acid would doubtless act as a corrosive poison, like the other mineral acids. Mr. Ure[6] observes, that as an escharotic "it is exceedingly convenient for application, inasmuch as it consists of a thick crystalline pap, which, when rightly managed, does not spread beyond the prescribed limits; and so soon as its erosive operation is finished, passes into the state of inert pulverulent sesquioxide." He employed it with success as an application to ulcerated piles. Its application was followed by acute burning pain and the formation of a slough: this became detached, the excrescence withered and shrunk, and the patients became perfectly relieved.—Chromic acid is employed as a bleaching agent for palm oil.[7] In the event of poisoning by chromic acid, the best antidotes would be probably a mixture of chalk and either milk or white of eggs and water (see *Potassæ Bichromas*).

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[1] *Histoire des Embaumements*, Paris, 1838.

[2] Mérat, *Supplément au Dict. Univ. de Mat. Méd.* p. 31, 1846.

[3] Warington, *Proceedings of the Chemical Society*, Dec. 7, 1841.

[4] *Chemical Gazette*, Oct. 1843.

[5] *Journal of the Philadelphia College of Pharmacy*, 1834; also, *Journ. de Chim. Méd.* t. x. p. 439, 1834.

[6] *London Medical Gazette*, March 21, 1845.

[7] Knapp's *Chemical Technology*, vol. i. p. 434.

91. Potassæ Chromates.—Chromates of Potash.

Two compounds of chromic acid are known—namely, the neutral chromate and the bichromate.

1. Potassæ Chromas; *Neutral, Yellow,* or *Monochromate of Potash ; Kali Chromicum flavum*, KO,CrO^3; Equivalent Weight 100.—Prepared by igniting a mixture of 4 parts of native chromite of iron (*chrome-iron ore*) and 1 part of nitre, dissolving out the chromate of potash by water, and crystallizing. Sometimes Chili saltpetre (nitrate of soda) is substituted for nitrate of potash, and chromate of soda, instead of chromate of potash, obtained. Chromate of potash forms yellow, prismatic, anhydrous crystals belonging to the right rhombic prismatic system. Their taste is cooling, bitter, styptic, and metallic. Erdmann[1] states that chromate of soda adulterated with sulphate of soda is sometimes substituted for chromate of potash. Crystals of chromate of soda contain about 52 per cent. of water, whereas those of chromate of potash are anhydrous. The local action of chromate of potash is irritant and caustic. Swallowed in large doses, it acts as an irritant and caustic poison. In smaller doses it occasions vomiting, and is used as an emetic instead of tartarized antimony, than which it less frequently purges. After its absorption, it acts specifically on the mucous surfaces, especially the conjunctiva and the bronchial and nasal mucous membranes, which it irritates and even inflames, and whose secretions it augments; and also on the nervous system, causing paralysis and convulsions. C. G. Gmelin[2] states that a drachm of it in powder introduced into the cellular tissue under the skin of the neck, caused on the first day dulness and disinclination for food; on the second day vomiting of a frothy mucus, and the secretion of a puriform mucus from the conjunctiva; on the third day vomiting, weakness of the hind extremities, staggering; on the fourth day difficulty of breathing and swallowing; on the fifth day he could scarcely stand on his feet; and on the sixth he died. The larynx, bronchi, and small bronchial tubes, contained membranous, polypous, and stringy masses of fibrinous mucus tinged with blood. The nose was filled with a puriform mucus, and the conjunctiva was inflamed and covered with the same kind of secretion. Berndt[3] has also made some experiments with it. He found its effects similar to, but somewhat milder than, those of the bichromate. Chromate of potash has been employed medicinally by Jacobson, Jensen, Radius, and Holscher.[4] Internally, it has been employed as an emetic both in adults and children, as a substitute for tartarized antimony. It has also been administered as an expectorant and diaphoretic in catarrh. Externally, it has been applied as a caustic to destroy fungous growths, excrescences, and nævi. A solution of one part of it in ten parts of water has been dropped into the eye twice daily in pustular rheumatic ophthalmia. A solution of it has also been used as a topical application to ulcers, scalled head, and pityriasis versicolor. Bibulous paper soaked in a solution of three drachms of this salt in two ounces of distilled water, dried, rolled into a cylindrical form, and fastened by mucilage, has been employed as a moxa. It developes a strong heat, and is said to burn without requiring to be blown upon. Lastly, a solution of one drachm of the salt in thirty-two ounces of water has been used as an antiseptic liquor (*liquor conservatrix*) both for living and dead parts.—Dose, as an emetic, from two to four grains for adults; and from a grain to a grain and a half for children. If three grains of it be dissolved in two ounces of water, a table-spoonful may be administered every ten minutes until vomiting is provoked. As an expectorant and alterative, the dose is from an eighth to half of a grain. Externally, it is employed either in the form of powder or in solution: the solution consists of from ʒss. to ʒiss. of the salt to f℥j. of water.—Antidote, see *Potassæ Bichromas*.

2. Potassæ Bichromas; *Bichromate of Potash ; Kali Chromicum rubrum*, $KO,2CrO^3$; Equivalent weight 152.—Obtained by adding sulphuric, nitric, or acetic acid to a solution of the neutral chromate, and setting aside the solution to crystallize. It forms orange-red, anhydrous, quadrangular prismatic crystals, soluble in 10 parts of cold, and in less of hot water, but insoluble in alcohol. This salt has been used as a source of oxygen (see *ante*, p. 268). Its taste is cooling, bitter, and metallic. Its topical action is that of an irritant and caustic. Its solution irritates the skin. In workmen who habitually employ it, it occasions an eruption of papulæ, which after a little time become pustular, and, if the use of it be continued, the pustules degenerate into sloughs, and painful ulcers are in this way formed.[1] Baer[2] states that troublesome ulcers are produced by it wherever the slightest erosion of the skin exists. Introduced into the stomach, or applied to wounds of animals, it causes vomiting, difficulty of respiration, paralysis, convulsions, and death.[3] In the human subject several fatal cases of poisoning by it have occurred. In some it appeared to kill by its irritant and caustic effects on the stomach and bowels.[4] At other times death has occurred independently of these effects, and from the action of the poison either on the blood or on the nervous system.[5] Toxicological writers usually ascribe it to an action on the nervous system; but the influence of this and other poisons on the blood, as a cause of death, deserves more attention than has hitherto been paid to it. Death by necræmia is, I suspect, of more frequent occurrence than is commonly supposed. Bichromate of potash has been used as an external agent only. Dr. Cumin thinks that if it were cautiously administered internally "it may be found, like arsenic, to possess considerable tonic virtues." He used a saturated solution of it as an application to tubercular elevations, excrescences, and warts. "In these cases the new growth has sometimes been removed by absorption without any slough; but where a slough has formed, it has always served to expedite the cure, and in no instance have I seen it to be followed by a deep or unmanageable ulceration." In one case it "was the only remedy which acted effectually without causing such intolerable pain as to preclude the continuance of its application." Hauche[6] found it useful for removing syphilitic excrescences without producing scabbing or suppuration. It promoted the cicatrization of ulcers, and proved useful in scrofula and cancer uteri.—For external use it has been employed either as a caustic in the form of powder, or in that of aqueous solution. The latter is made by dissolving from ʒss. to ʒj. of the salt in f℥j. or f℥iss. of distilled water. Cumin employed a saturated solution.—Berndt tried the effects of carbonate of potash, sulphate of iron, and tincture of galls, as antidotes; but they did not in any way neutralize the effects of the poison. In a case of poisoning by it, the best treatment would be probably a mixture of either chalk or magnesia with either milk or the whites and yolks of eggs mixed up with water. If vomiting be not present, emetics may be administered.

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[1] *Pharmaceutisches Central-Blatt für* 1844, p. 15.

[2] *Versuche über die Wirkungen des Baryts, Strontians, Chroms,* &c. Tubingen, 1824. Ducatel, Orfila, and several other writers, quote the experiments of Gmelin on bichromate of potash; but the only chromate whose effects are noticed in the above work is the neutral chromate (*neutrales chromsaures kali*).

[3] *British and Foreign Medical Review*, vol. vii. p. 565, 1839.

[4] See Dierbach, *Die neuesten Entdeckung in der Materia Medica*, Bd. i. S. 489, 1837; also, Bd. iii. S. 833, 1847. Likewise Aschenbrenner, *Die neuern Arzneimittel*. 1848.

ORDER XIX. COMPOUNDS OF MANGANESE.

Manganese, Manganesium, or *Manganum* ($Mn=28$), is the metallic basis of several compounds which have been employed in medicine.

92. MANGANESII BINOXYDUM.—BINOXIDE OF MANGANESE.

Formula MnO^2. *Equivalent Weight* 44.

HISTORY.—Native binoxide of manganese has been long known and used in the manufacture of glass (*magnesia vitriariorum,* vel *magnesia nigra*); but until Kaim, in 1770, succeeded in extracting a peculiar metal from it, it was usually regarded as an ore of iron. It is commonly termed *native black* or *peroxide of manganese*, or for brevity *manganese*. It is the *manganesii binoxydum* of the London Pharmacopœia,—the *manganesii oxydum* of the Edinburgh Pharmacopœia.

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[1] See Dr. Duncan, in the *Edinb. Medical and Surgical Journal*, vol. xxvi. p. 134, 1826; also, Dr. W. Cumin, in the same journal, vol. xxviii. p. 301, 1827.

[2] Quoted by Ducatel, *Journ. of the Philadelphia College*, 1834.

[3] Berndt, *British and Foreign Medical Review*, vol. xii. p. 565, 1839.

[4] Baer, quoted by Ducatel.

[5] Wilson, *Lond. Med. Gaz.* vol. xxxiii. p. 734.

[6] Quoted by Riecke, *Die neuern Arzneimittel.* 1840.

NATURAL HISTORY.—The oxide of manganese used in chemistry and pharmacy is the native anhydrous binoxide, called by mineralogists *pyrolusite*. It is found in great abundance in Cornwall, Devonshire, Somersetshire, and Aberdeenshire, from whence much of what is met with in commerce is obtained. The principal mines of it are in the neighbourhood of Launceston, Lifton, and Exeter. The Upton Pyne mine, once celebrated for its oxide of manganese, has yielded scarcely any for several years past, if, indeed, it be not completely worked out. Pyrolusite is also found in Saxony, Hesse, Bohemia, Hungary, Silesia, France, and other countries of Europe. 50,000 cwts. are annually obtained in the neighbourhood of Ilmenau (Dierbach).

PREPARATION.—Native binoxide of manganese, after being raised from the mine, is broken into small pieces about the size of peas, and then washed to separate the earthy impurities. It is afterwards ground in mills to an impalpable powder.

PROPERTIES.—This mineral occurs massive, columnar, crystallized, and pulverulent: the form of the crystals is the right rhombic prism. The massive variety has sometimes a metallic lustre, but is generally dull and earthy; its colour is iron-black or brownish; it soils the fingers in handling it; its sp. gr. varies from 4·7 to 4·9; it is tasteless, odourless, and insoluble in water; it yields a black powder.

Characteristics.—When heated, it yields oxygen gas (see *ante*, p. 267). If it be mixed with common salt and sulphuric acid, and the mixture heated, chlorine is evolved (see *ante*, p. 367). Heated with sulphuric acid, it evolves oxygen, and forms a sulphate of the protoxide of manganese. It is infusible before the blow-pipe, dissolves in fused borax with effervescence, and colours the globule of an amethystine colour. If it be digested in hydrochloric acid until chlorine cease to be evolved, and the solution be slightly supersaturated with ammonia, we get rid of the sesquioxide of iron: the filtered liquid throws down a white precipitate with ferrocyanide of potassium.

COMPOSITION.—Pure binoxide of manganese has the following composition:—

	Atoms.	*Eq. Wt.*	*Per Cent.*	*Forchammer.*	*Berz. & Arfvedson.*
Manganese	1	28	63·64	63·65	64·02
Oxygen	2	16	36·36	36·35	35·98
Binoxide of Manganese	1	44	100·00	100·00	100·00

PURITY.—The native binoxide is, however, never pure;—it usually contains oxide of iron, carbonate of lime, sulphate of baryta, and argillaceous matter. Its purity is judged of by the quantity of oxygen which it is capable of yielding (see *ante*, p. 267), or of the quantity of chlorine set free when this oxide and hydrochloric acid are allowed to act on each other. The quantity of chlorine set free can be estimated by the quantity of protosulphate of iron which it peroxidizes.[1] The brown varieties are inferior to the black ones.

Muriatic acid aided by heat dissolves it almost entirely, disengaging chlorine: heat disengages oxygen.—*Ph. Ed.*

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[1] Graham, *Elements of Chemistry*, p. 536.

PHYSIOLOGICAL EFFECTS.—The effects of this substance are imperfectly known. Kapp[1] regards it as a permanent stimulant, and says it promotes the appetite and digestion. Vogt[2] places it among the tonics, and considers it to be intermediate between iron and lead; but his views are altogether theoretical, as he does not seem to have employed it. Dr. Coupar[3] has described several cases of disease which took place among the men engaged in grinding it at the chemical works of Messrs. Tennant and Co. in Glasgow: from these it appears that, when slowly introduced into the system, it produces paralysis of the motor nerves. The disease commences with symptoms of paraplegia. It differs from the paralysis of lead in not causing colica pictonum or constipation,—and from mercury in first affecting the lower extremities, and in not exciting tremors of the affected part.

MANGANESIC ACID.—Hünefeld[4] gave to a rabbit nearly two drachms of manganesic acid in three days in doses of ten or fifteen grains. The only obvious effect was increased secretion of urine. The animal being killed, the peritoneum and external coat of the colon were found of a greenish colour [protoxide of manganese is green], the muscles were readily lacerated and pale, the liver was inflamed, the bile increased.

USES.—It is rarely employed in medicine. It appears to have been employed in the last century in the treatment of inflammatory fevers.[5] Grille[6] long since observed that the workmen in the manganese mines at Macon were not subject to the itch; and that others who became affected with this disease were cured by working in the mines. This led him, as well as Morelot[7] and others, to employ it in cutaneous maladies. Kapp administered it, as well as the salts of manganese, internally as well as externally in the various forms of syphilis. He used it with benefit in herpes, scabies, and the scorbutic diathesis. Brera[8] gave it in chlorosis, scorbutus, hypochondriasis, hysteria, &c. Otto[9] administered it in cachectic complaints with favourable results. Odier[10] employed it in cardialgia. It has been applied as an absorbent in the treatment of old ulcers, as a depilatory, and as a remedy for skin diseases, especially itch and porrigo.[11] Kugler[12] employed it with benefit in scrofula.

In chemistry and pharmacy it is employed in the manufacture of oxygen, chlorine, and iodine. In the arts it is used by the bleacher for the production of chlorine; by the glass-maker to destroy the brown colour communicated to glass by iron, and to give an amethystine tint to plate glass; and by the potter for colouring earthenware.

ADMINISTRATION.—Internally, it has been given in the form of pills in doses varying from three grains to a scruple three or four times in the day. As a local agent, it has been used in the form of *gargle*, composed of two or three drachms of the finely-powdered oxide diffused through five or six ounces of barley-water. An *ointment* consisting of one or two drachms of oxide to half an ounce or an ounce of lard has also been used.

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[1] *Hufeland's Journ.* Bd. xix. St. 1, S. 176.

[2] *Pharmakodynamik.*

[3] *Brit. Ann. of Med.* Jan. 13, 1837, p. 41.

[4] Horn's *Archiv. f. Med.* Erf. 1830, quoted by Wibmer, *Wirk. d. Arzn.*

[5] Schrodter, V.I.C.A. *Diss. num magnesia vitriariorum in febribus inflammatoriis adhibenda sit?* Jenæ, 1793 (Mérat et De Lens, *Dict. de Mat. Méd.*)

[6] *Ann. de Chimie*, xxxiii. 74.

[7] Grille et Morelot, *Quelques Avis sur l'Emploi de l'Oxyde Manganèse dans les Maladies Cutanées*, Grenoble, Am. 8; *Recueil des Actes de la Société de Santé de Lyon*, t. ii. p. 62.

[8] Harless, *Neues Journ. d. Ausl. Med. Lit.* Bd. viii. St. 2, S. 57.

[9] Froriep's *Notizen*, Bd. xii. No. 22, S. 347.

[10] *Handb. d. pr. Arzneiwiss.* quoted by Richter.

[11] Rayer, *Treatise on Skin Diseases*, by Willis, p. 58.

[12] Dierbach, *Die neuesten Entdeck. in d. Mat. Med.* Bd. iii. S. 843, 1847.

93. Manganesii Carbonas.—Carbonate of Manganese.

Formula MnO,CO^2. *Equivalent Weight* 58.

Manganum Carbonicum.—Occurs native as *diallogite* or *spathose manganese.* Found in small quantities in some mineral waters, as those of Carlsbad, Marienbad, Franzensbad (or Eger), Königswart, Alexisbrunnen, Altwasser, Ems, Driburg, &c. Obtained in the form of hydrate by precipitation from the protochloride or protosulphate of manganese by the carbonates or bicarbonates of potash or soda. It should be washed with boiled water and dried in vacuo over sulphuric acid. If washed with water containing air, and dried in the air, a portion of the salt is converted into the hydrated sesquioxide of manganese, which gives it a brownish or pale red tint. Hydrated carbonate of manganese is a snow-white, odourless, tasteless powder, which is insoluble, or nearly so, in water. It consists of $2(MnO,CO^2)+HO$. The medicinal powers of this salt are scarcely known. Wibmer[1] gave six grains of it to rabbits daily for many weeks without observing any effects therefrom. The animal was killed, but neither in the blood nor muscles could any chemical changes be detected. The dose of it for adults is from gr. x. to ℈j.

94. Manganesii Sulphas.—Sulphate of Manganese.

Formula MnO,SO^3. *Equivalent Weight* 76.

Manganum Sulphuricum.—Found in some mineral waters, as those of Cransac in France, and of the Alexisbad in Germany. It may be obtained by dissolving carbonate of manganese in diluted sulphuric acid, filtering and evaporating the solution so as to yield crystals. [illegible] by dyers and calico-printers. A solution of it entirely free from iron is prepared for them "by igniting the peroxide of manganese, mixed with about one-tenth of its weight of pounded coal, in a gas retort. The protoxide thus formed is dissolved in sulphuric acid, with the addition at the end of a little hydrochloric acid; the sulphate is evaporated to dryness and heated again to redness in the gas retort. The iron is found after ignition in the state of peroxide and insoluble, the persulphate of iron being decomposed, while the sulphate of manganese is not injured by the temperature of ignition, and remains soluble. The solution is of an amethystine colour, and does not crystallize readily."[2] The anhydrous salt is a white, friable mass, having a bitter, metallic taste, and being soluble in two parts of water at 59°, but insoluble in alcohol. Crystallized sulphate of manganese contains water, the quantity of which varies with the temperature at which the crystals are formed. These, obtained by gentle evaporation at a temperature of from 68° F. to 86° F., consist of $MnO,SO^3,4HO$; those formed between 45° and 68° consist of $MnO,SO^3,5HO$; while those produced below 43° are composed of $MnO,SO^3,7HO$.

C. G. Gmelin[3] tried the effect of the sulphate of the protoxide of manganese on animals, and found that it caused vomiting, paralysis without convulsions, and inflammation of the stomach, small intestines, liver, spleen, and heart. He notices, as a remarkable fact, "the extraordinary secretion of bile produced by it, and which was so considerable that nearly all the intestines were coloured yellow by it, and the large intestines had a wax-yellow colour communicated to them." Dr. C. G. Mitscherlich[4] has also examined its effects on animals, and has arrived at the conclusion that it destroys life by its caustic action on the stomach. Unlike alum, tannic acid, and the salts of iron, it does not form insoluble compounds with the constituents of the epithelium, but compounds which are soluble in water, thus acting like potash and soda. In rabbits poisoned by half an ounce of this salt, the mucous membrane was in many places destroyed and dissolved, in consequence of which blood was poured out.

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[1] *Die Wirkung der Arzneimittel und Gifte*, Bd. iii. S. 270, 1837.

[2] Graham, *Elements of Chemistry.*

[3] *Versuche über die Wirkungen des Baryts*, &c. 1824.

[4] *Lehrbuch der Arzneimittellehre*, Bd. i. S. 338, 1840.

Mr. Ure,[1] who tried its effects at my suggestion, found that, in doses of one or two drachms, it acted as a purgative and cholagogue. One drachm of it dissolved in about half a pint of water, and taken in the morning fasting, usually occasions after the lapse of an hour or so one or more liquid bilious stools. Its action is prompt and soon over, and does not occasion the depression which mercurials and antimonials produce in some constitutions. Infusion of senna is a useful adjunct. In some cases sulphate of manganese occasions vomiting and sweating as well as purging.

Sulphate of manganese has been employed in medicine both internally and externally. Ure, Goolden, and Dieterich, administered it as a purgative and cholagogue in torpid states of the liver, in jaundice, gout, &c. Kapp used it externally in the form of ointment, as a substitute for mercurial ointment, in buboes and chancres, and also in chronic cutaneous diseases.

As an alterative, it is given in doses of from five grains to a scruple; as a purgative, from ʒj. to ʒij. Dr. Thomson[2] says it may be given as a cathartic in doses of from ℥ss. to ℥j. He says he has seen an ounce swallowed without any effect except the free action of the bowels.[3] Such large doses are, however, scarcely safe. Externally, it has been used in the form of ointment, composed of ʒj. of the sulphate to ℥j. of lard.

The Sulphated Ferro-Manganesian Waters of Cransac[4] have been before alluded to (see *ante*, p. 297). Although a very considerable number of springs, especially chalybeate waters, contain manganese (as carbonate, sulphate, or chloride), the quantity is usually very small. The Karlshaller spring at Kreuznach contains little more than half a grain (0·6538 gr.) of the chloride of manganese in 16 oz. of water; and this, with the exception of the Cransac water, is the richest manganesian water at present known. The Cransac waters, however, contain nearly as much of manganese as of iron. They have been analyzed by MM. O. Henry and Poumarède. From their report it appears that the medicinal springs of this place are of two kinds—one strong, the other mild. Their composition is as follows:—

	Source haute, ou forte Richard.	*Source douce, ou basse Richard.*	*Source douce, ou basse Bezelgues.*
Sulphate of Manganese	1·55	0·14	0·41
" the Sesquioxide of Iron	1·25	0·15	
" Alumina	0·47	1·15	0·95
" Lime	0·75	2·43	1·21
" Magnesia	0·99	2·20	1·12
Black Bituminous Organic Matter		0·02	
Silica	0·07	0·02	
Water	994·92	993·89	996·31
	1000·00	1000·00	1000·00

From these analyses it follows that the stronger waters should possess hæmatinic (see *ante*, p. 188), tonic, astringent, and cholagogue properties; in other words, the essential effects of sulphate of the sesquioxide of iron and of the sulphate of manganese. The milder waters possess these properties in a very much less degree, in consequence of the smaller proportion of iron and manganese which they contain. But, on account of the larger quantity of sulphate of magnesia, they are purgative.

As chalybeates, the Cransac waters are, therefore, indicated in debility and all those maladies accompanied by anæmia (see *ante*, p. 191); as manganesian waters, they are adapted for torpid conditions of the liver, jaundice, &c.; while, on account of the purgative salt which it contains, the milder Cransac water is fitted for acting as a gentle aperient and promoter of secretion in various disordered conditions of the alimentary canal accompanied with confined bowels and sluggish liver.

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[1] *London Medical Gazette*, Nov. 1844.

[2] *Chemistry of Inorganic Bodies*, vol. ii. p. 587.

[3] Dr. Coupar, *Brit Ann. of Medicine*, Jan. 13, 1837.

[4] Cransac is a village in the department of Aveyron, part of the old Guyenne, about 140 miles east of Bordeaux, and 80 miles north of Toulouse (Dr. Ducoux, *Mineral Waters and Vapour Baths of Cransac*, Lond. 1847). Its name is derived from the phrase *curans aqua* (curing water), corrupted into Cransac. (Auzony, *Aperçu sur les Minérales et les Eluves de Cransac*. Thèse pour le Doctorat en Médicine, 17 Juin, 1843. Faculté de Méd. de Paris).

95. Manganesii Chloridum.—Chloride of Manganese.

Formula $MnCl$. *Equivalent Weight* 63·5.

Manganesii Hydrochloras; Muriate of Manganese; Manganum Chloratum.—Occurs in some mineral waters, as those of Karlshaller at Kreuznach. It may be procured by dissolving carbonate of manganese in hydrochloric acid. It is obtained as a secondary product in the manufacture of chlorine from peroxide of manganese and hydrochloric acid. The residuary liquor in this process contains chloride of manganese and perchloride of iron. To separate the latter, first boil down the liquid to drive off the excess of acid. Then dilute with water and add carbonate of manganese, which decomposes the perchloride of iron, precipitates peroxide of iron, and yields chloride of manganese in solution. One-fourth of the impure solution should be reserved to yield, on the addition of carbonate of soda, a sufficient quantity of carbonate of manganese to deprive the remaining three-fourths of the solution of its iron. The purified solution of chloride of manganese yields, on evaporation, rose-red or colourless crystals of the hydrated chloride of manganese, $MnCl,4HO$. If these be gradually heated, the whole of the water is driven off, and the anhydrous chloride remains. It is a rose-coloured, lamellar, deliquescent, inodorous salt, having an astringent saline taste, and being easily soluble both in water and alcohol. Its effects are analogous to those of the sulphate of manganese. It has been employed both externally and internally. In scorbutic affections, and syphilitic ulceration of the mouth and throat, Kapp employed a solution of it as a gargle. Internally it has been employed in chronic cutaneous affections. Osborn gave an alcoholic solution of it internally to repress hemorrhage from the nose. The dose of it is from gr. iij. to gr. x., in watery or alcoholic solution, in powder, or in pills. For gargles, a solution of from ʒj. to ʒiij. in a pint of water may be employed. Osborn's mode of using them was as follows:—One ounce of carbonate of manganese is to be dissolved, by the aid of heat, in two ounces of hydrochloric acid; and to the cold and filtered solution one ounce of alcohol is to be added. Of this solution, from ten to fifteen drops may be taken thrice daily, until a feeling of giddiness is perceived. When it is desired to stop the hemorrhage quickly, from ten to twenty drops may be taken every four hours.

96. Manganesii Acetas.—Acetate of Manganese.

Formula $MnO,C^4H^3O^3$; or $MnO,\bar{A}$. *Equivalent Weight* 87.

Manganum Aceticum.—Obtained by dissolving carbonate of the protoxide of manganese in concentrated acetic acid, and evaporating the solution so that it may yield crystals. Calico-printers procure it by mixing sulphate of manganese with acetate of lime. $MnO,SO^3+CaO,\bar{A}=MnO,\bar{A}+CaO,SO^3$. This salt forms transparent, pale-red, rhomboidal tables, which are permanent in the air, and whose taste is astringent and metallic. It is soluble in 3½ parts of water, and also in alcohol. It has been used in medicine by Kapp as one of the milder manganesic preparations. The dose is from five to ten grains. A solution of one scruple of this salt in three ounces of water has been employed as a gargle in aphthæ.

ORDER XX. ARSENIC AND ITS COMPOUNDS.

97. Arsenicum.—Arsenic.

Symbol As. *Equivalent Weight* 75.

Although metallic arsenic is not used in medicine, yet as it is a poisonous substance (or, at least, acquires poisonous properties), and as, in medico-legal inquiries respecting arsenical poisoning, its production is necessary in order to establish the presence of an arsenical compound, some notice of it here is requisite.

Arsenic is peculiar to the mineral kingdom.[1] It occurs in the metallic state, and in combination with oxygen, with sulphur, and with other metals. There are two native compounds of it with oxygen—namely, *arsenious acid* and *arsenic acid*, the latter being found in combination with bases, forming *arseniates*. Two sulphurets, also, are found native—namely, *orpiment* and *realgar*. It has also been found in some mineral waters.[2]

On the large scale it is obtained by heating mispickel (arsenical pyrites), $FeAs,FeS^2$, in earthen tubes or tubular retorts: metallic arsenic, As, sublimes, leaving behind sulphuret of iron, 2FeS.—On the small scale it is usually obtained by sublimation from a mixture of arsenious acid and charcoal, or of arsenious acid and black flux (see *ante*, p. 474). The acid is deoxidized by the carbon. $2AsO^3+3C=2As+3CO^2$. The potassa of the black flux serves to prevent the volatilization of the arsenious acid until this has acquired a sufficient temperature for its perfect reduction by the carbon.—Metallic arsenic may also be obtained by heating arsenic acid or a sulphuret of arsenic with black flux: if a sulphuret of arsenic be employed, the products are an alkaline sulphuret, carbonic acid, and metallic arsenic, which sublimes. $2AsS^3+6KO+3C=2As+3CO^2+6KS$.

Metallic arsenic is hard, very brittle, and crystalline. The form of its crystal is the rhombohedron (see *ante*, p. 140). The colour of the metal varies from tin-white to steel-grey. It possesses considerable brilliancy, but soon tarnishes in the air, and becomes dull and dark grey. Sp. gr. 5·6 to 5·9. At a low red heat it volatilizes without fusing, and yields a vapour having an alliaceous odour: in the open air this vapour becomes oxidized, and yields white fumes of arsenious acid. The physical characters of the metal differ somewhat, according as this exists in the mass, in the form of a ring lining a glass tube, or in that of a spot on a plate of glass, porcelain, or mica.

Metallic arsenic is recognised by the following characters:—1, its volatility; 2, its conversion into a white volatile powder (arsenious acid) when heated in a tube open at both ends, and held in an inclined position; 3, its conversion into arsenic acid, with the evolution of binoxide of nitrogen gas when it is heated with nitric acid: *a*, when the nitric solution is cautiously evaporated to dryness, and the white solid residue (arsenic acid usually mixed with a small portion of arsenious acid) is touched with a concentrated solution of nitrate of silver, a brick-red arseniate of silver is produced; *β*, and if another portion of the white residue be dissolved in water, the solution acidulated by hydrochloric and sulphurous acids, and washed sulphuretted hydrogen gas be transmitted through it, a yellow precipitate (*orpiment*) is obtained, which is insoluble in water, but soluble, with decolouration of the liquid, in a solution of ammonia.

Metallic arsenic, when swallowed, is capable of acting as a powerful poison,[3] probably by becoming oxidized and converted into arsenious acid.

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[1] The statements of Orfila and Couerbe (*Journ. Chim. Méd.* tom. v. 2e Sér. pp. 462 and 632, 1839; also, *Lond. and Edinb. Phil. Mag.* April 1840), and of Devergie (*Méd. Légale*, 2e édit. t. iii. p. 449), that the bones and muscles of healthy men, as well as the bones of healthy horses, oxen, and sheep, contained arsenic (called *normal arsenic*), have not been confirmed by the experiments of Dr. G. O. Rees (*Guy's Hospital Reports*, xii.); of Danger and Flandin, and of Chevallier (*Journ. Chim. Méd.* t. vii. 2e Sér. p. 84, 1841); of the Commissioners appointed by the French Academy to report on Marsh's apparatus (*Journ. de Pharm.* t. xxvii. p. 428, 1841); of Barbet, Faure, and Magonty (*Ibid.* p. 654), as well as of others. Orfila himself now admits that he cannot procure arsenic from bones (*Traité de Toxicologie*, t. i. p. 438, 1843).

[2] *Journal de Chim. Méd.* tom. v. 2e Sér. p. 183, 1839; *Chemical Gazette*, vol. v. pp. 53 and 334, 1847; and *Repertoire de Pharmacie*, t. iii. p. 176, 1846.

[3] Orfila, *Journ. de Chim. Méd.* t. v. 2e Sér. p. 3, 1839; and *Traité de Toxicol.* t. i. p. 304, 4me édit. 1843.

The substance sold on the continent as *fly-powder* (*poudre aux mouches; Fliegengift*) is essentially metallic arsenic (called *cobalt*, or *cobaltum crystallizatum*) which has become partially oxidized by exposure to the air. It resembles the black or suboxide of arsenic, AsO, and is usually regarded as being a mixture of metallic arsenic and arsenious acid, AsO^3.

98. ACIDUM ARSENIOSUM.—ARSENIOUS ACID.

Formula AsO^3. *Equivalent Weight* 99.

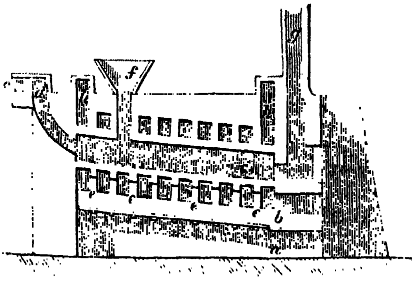
HISTORY.—Arsenious acid, commonly termed *white arsenic* (*arsenicum album*), or *oxide of arsenic* (*arsenicum oxydum album*), is first distinctly mentioned by Geber,[1] who seems to have been also acquainted with metallic arsenic.[2] Hippocrates[3] employed ἀρρενικόν (*orpiment*) and σανδαράκη (*realgar*) as topical remedies. Dioscorides[4] also mentions ἀρσενικόν (*orpiment*).

NATURAL HISTORY.—Native arsenious acid is found at Andreasberg in the Hartz, at Joachimstahl in Bohemia, and at some few other places. It is a rare mineral.

PREPARATION.—Arsenious acid is prepared in Silesia, Bohemia, Saxony, and Cornwall.

At Altenberg, in Silesia, it is obtained from arsenical iron (*mispickel*), composed of sulphur 20·65, iron 35·62, and arsenicum 43·73.[5] After being reduced to powder, the ore is roasted in a muffle furnace (fig. 112), by which the arsenicum is converted into arsenious acid, which is conveyed, in the state

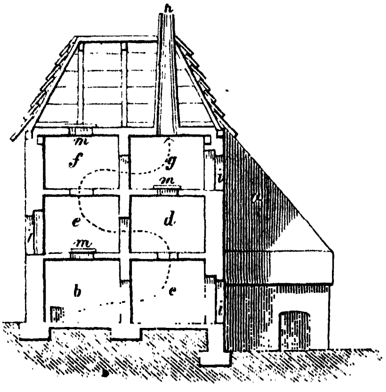
FIG. 112.



Section of the Roasting Furnace.

a. Ash-pit. *b.* Fire-place. *e, e, e.* Brick arches for supporting the muffle. *c.* Earthen muffle for receiving the ore. *d.* Passage for the fumes into the condensing chamber. *f.* Hopper for introducing the ore. *h, h.* Flue. *g.* Vent for protecting the workmen from the arsenical fumes.

FIG. 113.



Condensing Chamber.

b, c, d, e. f, g, h. Course of the vapour.
i, i, i. Doors into the chamber.
m, m, m. Communications between the floors.

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[1] *Invent. of Verity*, ch. vii.

[2] *Sum of Perfection*, book i. part iv. chap. ii.

[3] *De Ulceribus.*

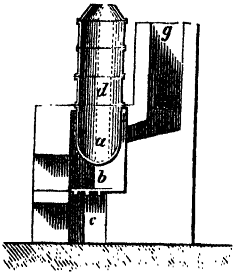
[4] Lib. v. chap. xxi.

[5] Dumas, *Traité de Chimie*, t. iv. p. 120.

of vapour called *flowers of arsenic* or *smelting-house smoke* (*Hüttenrauch*), into the condensing chamber (fig. 113), where it is deposited in a pulverulent form; and in this state is called *rough arsenious acid* or *poison-flour* (*Giftmehl*).

The rough acid is refined by sublimation. This is effected in cast-iron pots (fig. 114), to which cylindrical iron heads (*d*) are attached, which at the tops are contracted into cones (*e*), each terminating in a pipe made of sheet iron, and communicating with the condensing chamber (fig. 113). Heat is applied for twelve hours, by which the acid is sublimed and condensed on the sides of the iron head in the form of a glassy mass, called *glacial white arsenic* (*weissen Arsenikglas*), which is sometimes purified by a second or even third sublimation. If it contain any sulphuret of arsenicum, a little potash is mixed with it to prevent the sublimation of the sulphur.

FIG. 114.



Refining Furnace.

c. Ash-pit. *b.* Fire-place.
a. Cast-iron pot.
d. Cylindrical head.
g. The chimney.

At Reichenstein, arsenious acid is procured from an arseniuret of iron, composed of iron 32·35, arsenic 65·88, and sulphur 1·77.

Arsenious acid is procured in some parts of Saxony as a secondary product in the roasting of cobalt ores (the arseniurets of cobalt). It is deposited in long horizontal flues (*poison-flues*, or *Giftfängen*), and is purified by sublimation.[1]

Arsenious acid is manufactured in Cornwall, from the *white mundic* or *mispickel* found with the tin ore. In the impure state it is deposited in the long horizontal flues of the burning houses;[2] from which it is taken for the use of refiners, its value being about ten shillings per ton.[3] In this condition it has a grey colour, and is either pulverulent or in soft crystalline masses.

The rough arsenious acid is brought to the arsenic works from the burning-houses in different parts of Cornwall. It is first separated from sulphur in a common reverberatory furnace, having a flue several hundred yards in length. The heat is low at first, and is gradually increased. By this means the sulphur is dissipated before the arsenic is volatilized. The process is carried on for several weeks, or even months. The fire is then extinguished, and the arsenic removed from the flue. The waste rubbish is used for destroying weeds, &c. in garden walks.

The arsenious acid thus obtained is then sublimed in conical cast-iron *kettles*, about 2½ feet high, and from 15 to 18 inches in diameter at the base. These kettles are hollow truncated cones, closed at the top by an iron plate perforated for an iron stopper; but open at the bottom. Ten or twelve of these kettles are placed in a circular form on an iron plate, to which they are clamped by a flange. This plate forms the bottom to all the kettles, and is heated by a fire beneath. The rough arsenic is then introduced through the top aperture, and, heat being applied, is sublimed. Several charges are in this way introduced, until a sufficiently thick crust has been deposited within: the clamps are then taken off, and the kettle conveyed into the open air, where the crust is removed.[1] The fumes from these Works are most injurious to neighbouring vegetables and animals. In the human subject eruptions, principally about the lips and nose, are produced by them.[2]

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[1] For further particulars, consult the paper of J. H. Vivian, *Trans. Royal Geol. Society of Cornwall*, i. 60.

[2] Mr. J. Taylor, *Ann. Phil.* N.S. iii. 452.

[3] *Quart. Min. Rev.* vol. ii. p. 88; and Mr. Davies Gilbert, *Paroch. Hist. of Cornwall*, iii. 305.

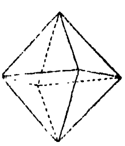
In 1826, eighty-three tons of manufactured arsenic were shipped at Penryn.[3] In 1842, Mr. Henwood stated that not less than from 600 to 800 tons were prepared annually.

PROPERTIES.—Arsenious acid occurs both crystallized and amorphous.

1. *Crystallized arsenious acid.*—Arsenious acid, AsO^3, is *isodimorphous;* that is, it crystallizes in two distinct forms (dimorphous), both of which are isomorphous with the oxide of antimony, SbO^3.

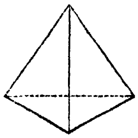
a. Octohedral arsenious acid.—This is the usual crystalline form of white arsenic. It may be readily obtained in this form by sublimation (see fig. 117, p. 643), as well as by cooling a boiling saturated aqueous solution. The crystals are transparent, and are usually regular octohedrons (fig. 115), or sometimes tetrahedrons (fig. 116). The conversion of transparent glacial arsenious acid into the opaque, enamel-like acid is probably the passage of the amorphous to the crystalline state.

FIG. 115.



Regular Octohedron

FIG. 116.



Regular Tetrahedron.

β. Right rhombic arsenious acid.—Wöhler found in a cobalt-roasting furnace arsenious acid crystallized in hexahedral plates derived from a right rhombic prism. By sublimation, as well as by solution in hot water, these crystals yielded octohedrons and tetrahedrons.

2. *Amorphous arsenious acid.*—When recently prepared, arsenious acid is in the form of large, glassy, colourless or yellowish, transparent cakes (*vitreous* or *glacial arsenious acid*). Frequently the cakes consist of concentric laminæ, formed by successive sublimations. These masses soon become opaque and white externally, like enamel (*opaque* or *enamel-like arsenious acid*), the opacity gradually extending towards the centre; and, in some cases, the acid becomes friable and pulverulent. Krüger[4] ascribes the change to the absorption of water from the atmosphere, for he says it only takes place in moist air, and is attended with an increase of weight, but only to the extent of $\frac{1}{100}$th of the whole mass. Mr. Phillips[5] has taken the same view of the subject. I had some arsenious acid which has remained transparent for more than two years in a glass tube hermetically sealed: the tube was subsequently cracked, and then the acid became opaque. This fact is confirmatory of the opinion just stated.[6] The change from the transparent

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[1] Henwood, in *The Seventh Annual Report of the Royal Cornwall Polytechnic Society*, Falmouth, 1839. Part of the above information was obligingly communicated to me, *vivâ voce*, by Mr. Henwood.

[2] For this and some other information, as well as for samples of the rough arsenious acid from Wheal Vor tin mine, I am indebted to Mr. Ferris, surgeon, of Truro.

[3] *Transactions of the Royal Geological Society of Cornwall*, iii. 360.

[4] *Kastn. Arch.* ii. 473, quoted in Gmelin's *Handb. d. Chem.*

[5] *Transl. of the Pharm.* 4th edit.

[6] In the first edition of this work, I stated that arsenious acid became opaque in an air-tight vessel. I have since had reason to believe that the bottle referred to was not completely air-tight, though covered by a varnished bladder.

to the opaque state is by some persons regarded as the transformation from the amorphous to the crystalline condition, the opacity depending on the presence of a multitude of very small crystals. It is remarkable, however, that the density is diminished, while, according to some, the solubility is increased, according to others it is decreased, by this transition.

Professor Guibourt,[1] Mr. Phillips, and Dr. Taylor, have each found the density of the opaque variety to be less than that of the transparent. *Transparent* arsenious acid has a sp. gr. of 3·7391, according to Guibourt (3·715, Phillips; 3·208 to 3·333, Mitchell and Durand; 3·798, Taylor). It dissolves, according to the same authority, in 103 parts of water at 59°, or in 9·33 parts of boiling water, and the solution feebly reddens litmus. *Opaque* arsenious acid, on the other hand, according to Guibourt, has a sp. gr. of 3·695 (3·529, Taylor; 3·620, Phillips), is soluble in 80 parts of water at 59°, or in 7·72 parts of boiling water, and the solution restores the blue colour of reddened litmus; but I find that both kinds redden litmus, and Dr. Christison has observed the same. Dr. Taylor[2] did not find any difference in the solubility of the two varieties. He found that water perfectly cooled from a boiling saturated solution will retain from ten to twenty or more times the quantity of acid in solution than it will take up at common temperatures without heat. Bussy,[3] on the other hand, found the transparent acid to be at 55° F. about three times as soluble as the opaque acid. He describes the various anomalies observed in the solubility of arsenious acid to the mixture of the two varieties of the acid in the same solution; for by prolonged ebullition in water the opaque acid is rendered transparent, while under the influence of water and a low temperature the transparent is converted into opaque acid. Arsenious acid is soluble in alcohol and oils. It is of importance to know that the presence of organic matters very much impairs the solvent power of water for this acid—a circumstance which readily explains why arsenious acid has not, in some cases, been found in the liquid contents of the stomach of persons poisoned by it. Arsenious acid has little or no taste, as Plenck,[4] Addison, and Christison, have remarked: and neither in the solid nor vaporous form has it odour. At a temperature of 380° F. it volatilizes: when heated under pressure it liquefies, and is converted into a transparent glass.

Characteristics.—These may be conveniently and usefully discussed under three heads:—α. The characteristics of solid arsenious acid;—β. the characteristics of a pure solution of arsenious acid;—γ. the characteristics of arsenious acid in organic mixtures.

α. **Of Solid Arsenious Acid.**—The characteristics of solid arsenious acid are (besides its physical properties before mentioned), principally three,—its volatility, the garlic odour evolved by throwing it on ignited charcoal or cinder, and the qualities of the metallic crust obtained by reducing the acid.

1. *Its volatility.*—Heated on the point of a penknife in the flame of a spirit-lamp, arsenious acid produces a white smoke, and speedily disappears. If the acid be heated in a test tube of narrow bore, a crystalline sublimate is obtained: the crystals are sparkling, and, when examined by a magnifying glass,

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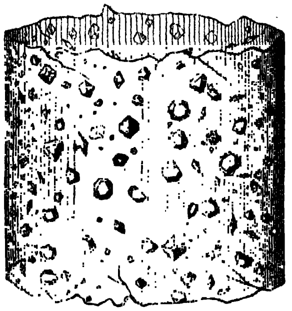
[1] *Journal de Chimie Méd.* t. ii. p. 57, Paris, 1826.

[2] *Guy's Hospital Reports*, vol. ii. p. 83.

[3] *Journ. de Pharm. et de Chim.* 3e Sér. xii. Nov. 1847.

[4] *Toxicologia*, ed. 2nda, 26.

FIG. 117.



Magnified portion of a tube lined by the sublimed crystals of arsenious acid.

are found to be regular octohedrons (see fig. 115) and their modifications (see fig. 117).

The *impediments* to the operation of this test are alkaline or earthy bases which retain a portion of the arsenious acid, and prevent its rising in vapour: boracic acid may be used to counteract their influence.

The *fallacy* of this test is, that other white solids (as corrosive sublimate, hydrochlorate of ammonia, oxalic acid, &c.) are volatile, and produce a white smoke when heated.

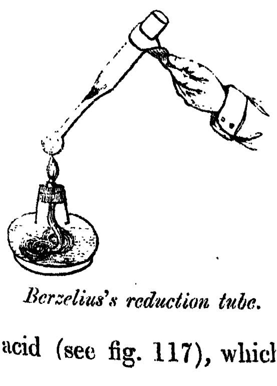
2. *Garlic odour.*—If arsenious acid, or an arsenite, be put on a piece of red-hot cinder or charcoal (placed for convenience in a saucer), it evolves a scarcely visible vapour (*metallic arsenic*), having a garlic odour, and which, at the distance of an inch or two from the cinder, is converted into a dense, white, odourless smoke (*arsenious acid*). The deoxidation of the acid is essential to the production of the garlic odour, $2AsO^3 + 3C = 2As + 3CO^2$; hence no odour is perceived when arsenious acid is placed on a heated metallic or glass plate, and is not in contact with any organic substance capable of effecting its reduction. The white smoke (arsenious acid) results from the oxidation of the metallic arsenic, $As + O^3 = AsO^3$.

The *impediment* to the action of this test is the presence of organic matter (as flour): this, by burning, developes a strong odour, which masks the smell of the vapour of the metallic arsenic.

The *fallacy* attending it is, that some other bodies (as phosphorus, with certain of its compounds and some organic matters) evolve when heated a garlic odour. Vauquelin, Barruel, and Orfila, have shown that a compound of albumen and fat, which exhaled this odour when heated, did not contain a particle of arsenious acid. "It is true," say these experimenters, "that arsenicum evolves a garlic odour when volatilised; but even when this is well characterised, it is insufficient to establish the existence of the oxide of arsenic, since it belongs to some other substances; and it is not impossible that there may be developed in the stomach, during digestion, substances which exhale an analogous odour, when heated."

3. *Formation of a metallic crust. Reduction test.*—If arsenious acid be intimately mixed with freshly-ignited but cold charcoal, or still better with a mixture of charcoal and carbonate of soda (as the residue obtained by incinerating in a covered crucible tartrate or acetate of soda), and heated in a glass tube, the acid is deoxidized, and yields metallic arsenic, which is sublimed into a cooler portion of the tube, where it condenses, and forms a metallic crust, $2AsO^3 + 3C = 2As + 3CO^2$. (see *ante*, p. 638). A common cylindrical test tube answers very well; but the reduction tube of Berzelius (fig. 118) is to be preferred. The characters of the arsenical crust (see *ante*, p. 638) are—the brilliancy of its outer surface, which is frequently equal to polished steel or looking-glass; the crystalline appearance and greyish-white colour of its inner surface; its volatility; its conversion, by sublimation, up and down the tube, into octohedral crystals of arsenious acid (see fig. 117), which may be dissolved in distilled water, and tested by

FIG. 118.



Berzelius's reduction tube.

the liquid re-agents presently to be mentioned; and its yielding arsenic acid (AsO^5) by dissolving it in nitric or nitro-hydrochloric acid, and carefully evaporating the solution to dryness. The arsenic acid is known by the red precipitate ($3AgO,AsO^5$, *arseniate of silver*) produced on the addition of nitrate of silver: but if the evaporation has not been carried on sufficiently far, some hydrochloric acid or chlorine will be left, which forms a white precipitate ($AgCl$, *chloride of silver*) with nitrate of silver. The arseniate of silver may be reduced, if necessary, by mixing it with charcoal and boracic acid, and heating it in a glass tube.

In some cases the metallic crust is imperfectly formed, or is masked by some decomposed organic matter. Whenever any doubt respecting its nature is entertained, proceed as follows:—Cut off with a file the portion of the tube which contains the suspected crust, roughly powder it, introduce it into another glass tube, and apply heat.

The metallic character of the crust is sometimes rendered more evident by applying to it, for a few seconds, the flame of the spirit-lamp, which drives off a black powder (*black* or *suboxide of arsenic*, AsO ?) and leaves the brilliant metal. If the heat be continued too long the metal itself sublimes.

This black oxide of arsenic is more volatile than metallic arsenic, but less so than arsenious acid.

The *fallacies* to which this test is liable are principally two—a charcoal crust may, by an inexperienced experimenter, be mistaken for the arsenical crust; and I have seen students confound a stratum of globules of mercury (obtained by reducing calomel) with the arsenical crust. Careful examination, especially by a magnifying glass, will, however, easily enable the experimenter to distinguish them: the inner surface of the charcoal crust is brown, powdery, and dull; whereas that of the arsenical crust has a crystalline texture, iron-grey colour, and shiny appearance; the sublimate obtained by reducing calomel or mercurial compounds has all the brilliancy of arsenicum, but by a glass is found to consist of minute globules which may be made to coalesce by the point of a knife. Lastly, the arsenical may be distinguished from all other crusts by oxidating it, as before directed, and converting it into arsenious or arsenic acid, which can be readily recognised by the tests already mentioned:—*a proceeding which ought never to be omitted.*

As a deoxidizing agent, freshly ignited charcoal alone may be employed to convert arsenious acid into arsenicum. The presence of the carbonate of soda or potash is useful by preventing the volatilization of the arsenious acid until it becomes sufficiently heated to suffer reduction by the carbon (see *ante*, p. 638). But on the other hand, when either of these salts is present, a portion of arsenicum is retained as arseniuret of sodium or of potassium: hence, when the quantity of acid to be reduced is small, charcoal alone has been recommended; but when the quantity of material is considerable, it is preferable to employ an alkaline flux. Soda-flux is preferable to potash-flux, (*i. e.* black-flux) because the latter attracts water from the atmosphere. Soda-flux may be prepared by accurately mixing bicarbonate of soda with charcoal, and heating the mixture to redness to drive off the water. If the substance to be reduced be an arsenite (as of silver, copper, or lime), or an arseniate (as of silver), a mixture of charcoal and boracic acid should be used. For the reduction of the arsenical sulphurets (as the precipitate obtained by passing hydrosulphuric acid gas through a solution of arsenious acid) a mixture of two parts of ignited carbonate of soda and one of charcoal should be employed. The alkali is here essential, in order to combine with the sulphur, $2AsS^3+6(NaO,CO^2)+3C=2As+9CO^2+6NaS$ (see *ante*, p. 638). Various other deoxidizing agents have been recommended; as formate of soda by Goebel,[1] oxalate of lime by Du Menil,[2] oxalate of soda by Dr. M'Gregor,[3] and cyanide of potassium. I find that quadroxalate of potash (see *ante*, p. 522) answers very well. None of these, however, present any advantage over charcoal save that of not soiling the tube (an occurrence easily avoided by using a glass funnel, as recommended by Dr. Christison, or which may be obviated by wiping the tube, after the introduction of the mixture, with a wisp of paper or feather), while their comparative scarcity and greater cost are objections to their employment.

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[1] Griffin's *Chem. Recreat.* 8th edit. 140.

[2] *Hand. d. Reag. u. Zerlegungslehre*, ii. 268, Lemgo, 1836.

[3] *London Medical Gazette*, xxii. 613.

β. **Characters of a pure Aqueous Solution of Arsenious Acid.**—When powdered arsenious acid is boiled in distilled water it very slowly dissolves, part of it floating on the surface of the liquid, or aggregating in small lumps at the bottom of the vessel. This character of white arsenic has sometimes become important in medico-legal investigations (see Dr. A. Taylor, *On Poisons*, p. 335).

A clear watery solution of arsenic has a very feeble acid reaction on litmus. Its taste is feeble. By evaporation on a glass plate it yields octohedral crystals (see *ante*, p. 643, page 117). It yields a white precipitate with lime water; a yellow colour, and, on the addition of hydrochloric acid, a yellow precipitate, with sulphuretted hydrogen water; a green precipitate with ammonio-sulphate of copper; a yellow precipitate with ammonio-nitrate of silver; it evolves arseniuretted hydrogen gas when mixed with zinc, and either sulphuric or hydrochloric acid (*Marsh's test*); and lastly, when boiled with hydrochloric acid and clean copper foil it gives a grey metallic coating to the latter (*Reinsch's test*). These tests require individual notice.

1. *Lime Water.*—Lime water ($CaO + Aq$) occasions a white precipitate (*arsenite of lime*, $2CaO,AsO^3$), with a solution of arsenious acid. The precipitate is soluble in most acids.

The *impediments* to the operation of this test are, a large quantity of water and free acids, which hold it in solution, and gelatinous and oleaginous liquids, which keep it suspended.

The *fallacies* of this test are, carbonates, oxalates, tartrates, &c. which also throw down white precipitates with lime water. On the whole, it is a test of very little value.

2. *Ammonio-sulphate of Copper.*—If a dilute solution of ammonio-sulphate of copper ($CuO,2NH^3,HO,SO^3$) be added to a solution of arsenious acid, a pale green precipitate (*arsenite of copper*, $2CuO, AsO^3$ [?], called *Scheele's green*), soluble both in nitric acid and ammonia, is obtained, and sulphate of ammonia, with excess of ammonia, remains in solution. This test is prepared as follows:—Add (cautiously) liquor ammoniæ to a solution of the sulphate of copper, so as to re-dissolve the oxide of copper, which it at first throws down. Care must be taken not to employ too much alkali, otherwise the test will not act. Moreover, the solution must not be concentrated, or no precipitate will be obtained. This test, though characteristic when cautiously applied, is not very delicate.

The *impediments* to the action of this test are astringents, as tea, infusion of galls, &c. which prevent its acting characteristically.

The *fallacies* to be guarded against are, yellow-coloured and other organic fluids, as decoction of onions, which give a green colour, and slight precipitate, even though no arsenic be present.

3. *Ammonio-nitrate of Silver: Hume's test.*—If a solution of ammonio-nitrate of silver ($AgO,2NH^3,NO^5$) be added to a solution of arsenious acid, a yellow precipitate (*arsenite of silver*, $2AgO,AsO^3$) takes place, and nitrate of ammonia, with excess of ammonia, remains in solution. The precipitate is soluble in liquid nitric acid, in solution of ammonia, and in solution of nitrate of ammonia. The mode of preparing this test is as follows:—Add a few drops of liquor ammoniæ to a solution of nitrate of silver, so that the oxide of silver which the alkali at first throws down may be nearly, but not entirely, redissolved (see *Solutio Argenti Ammoniati*, E.). Great care is requisite to add neither too much nor too little; for if too much be employed, the solution will not occasion any precipitate with arsenious acid; and if too little, it will produce a precipitate ($3AgO,cPO^5$) with phosphate of

soda ($2NaO,HO,cPO^5$), similar in colour to that produced with arsenious acid. The only certain way of knowing when the proper quantity has been employed is to test the solution. Arsenious acid, but not phosphate of soda, ought to occasion a precipitate with it. This test is more delicate than the preceding one.

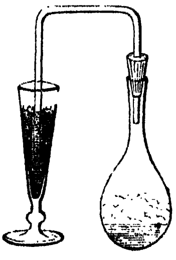
The *impediments* to the operation of this test are, free acids, (as hydrochloric, nitric, acetic, citric, or tartaric), chlorides, and organic matters. The acids may be readily neutralized by an alkali. If common salt, or other metallic chloride, be present, ammonio-nitrate of silver throws down a white precipitate ($AgCl$, *chloride of silver*), even though a considerable quantity of arsenic be present. To obviate this, add a few drops of nitric acid, then an excess of a solution of nitrate of silver. Filter to get rid of the precipitated chloride of silver, and apply the ammonio-nitrate of silver. The presence of much organic matter impedes the action of this test.

Ammonio-nitrate of silver, when properly prepared, does not occasion a yellow precipitate with any substance save arsenious acid; and hence is not subject to any *fallacy* of that kind. If, however, it be not properly prepared, it may occasion a yellow precipitate (*phosphate of silver*, $3AgO,cPO^5$) with phosphate of soda. There is an optical fallacy, against which the student ought to be put upon his guard: if ammonio-nitrate of silver be added to certain yellow liquids containing common salt, a white precipitate (*chloride of silver*) is produced, which, seen through a yellow medium, might, by a careless observer, be mistaken for a yellow precipitate.

4. *Hydrosulphuric acid* (*Sulphuretted Hydrogen*, HS.).—This test may be employed either in the gaseous form, or in the form of sulphuretted hydrogen water (see *ante*, pp. 363, 364); but the former is to be preferred.

If sulphuretted hydrogen water be added to a solution of arsenious acid, the liquid is rendered yellow; and on the addition of a few drops of a strong acid (as of hydrochloric acid) a yellow precipitate (*orpiment, tersulphuret of arsenic*, or *sulpharsenious acid*, AsS^3) falls. If the gas be passed through a solution of arsenious acid, a yellow precipitate (AsS^3) is produced, while the oxygen of the arsenious acid, and the hydrogen of the hydrosulphuric acid, unite to form water, $AsO^3+3HS=AsS^3+3HO$. In order, however, for this effect to be produced, it is necessary that the liquid be slightly acidified by some acid (as the hydrochloric). If the liquid be already acid, we must neutralize it by cautiously adding an alkali, and then acidify by hydrochloric acid.

Fig. 119.



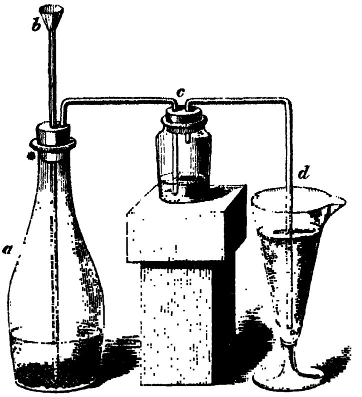
Mode of passing hydrosulphuric acid through an arsenical solution.

In applying this test we may place the suspected liquid in a test-tube, or conical wine or ale-glass (fig. 119); the gas being developed in a common Florence flask (or two-necked bottle): the mouth of the flask is closed by a cork, perforated by a tube curved twice at right angles.

There is, however, an objection to this mode of procedure: if the gas be disengaged too rapidly, it frequently carries over with it a portion of the ingredients (sulphuric acid and sulphate of iron, see *ante*, p. 363) employed in generating it. Hence it is desirable that it should be washed, by passing it through water, before it is allowed to come in contact with the arsenical solution. The following apparatus (fig. 120) is, therefore, to be preferred for this operation.

The ingredients for producing the gas are contained in the flask *a*, the acid being introduced by the funnel *b*. The disengaged gas is washed by being transmitted through the water contained in the bottle *c*, and is then conveyed into the arsenical solution contained in a conical test or ale-glass.

FIG. 120.



Apparatus for the passage of sulphuretted hydrogen through an arsenical solution.

The ingredients for developing the gas are a metallic sulphuret (as of iron or antimony) and sulphuric or hydrochloric acid. (For the etiology of the process, see *ante*, p. 363.) Sulphuret of iron and dilute sulphuric acid are to be preferred. After the gas has passed through the arsenical liquid for a few minutes, portions of the yellow tersulphuret of arsenic (*orpiment*) begin to fall down. The separation of the precipitate is promoted by ebullition, and the exposure of the solution for a few hours to the air.

The essential characters of the precipitate are, its yellow colour, its insolubility in hydrochloric acid, its rapid solution in liquor ammoniæ, forming a colourless and very limpid liquid, and its yielding metallic arsenic when dried and heated with either soda-flux or potash-flux. When the quantity of tersulphuret is small, some difficulty may be experienced in removing it from the filter for reduction. The readiest way is that recommended by Devergie: Collect it on the filter in as small a space as possible, then wash it with liquor ammoniæ, which dissolves it. The filtered liquid may then be evaporated in a capsule or watch-glass: the ammonia flies off, and leaves the sulphuret.

Hydrosulphuric acid produces yellow precipitates with some other substances, as well as with arsenious acid; and, therefore, the appearance of a yellow precipitate on the application of hydrosulphuric acid does not prove the presence of arsenic.

1. The salts of *cadmium* yield, with hydrosulphuric acid, a yellow precipitate, CdS; but this is insoluble in liquor ammoniæ, and soluble in hydrochloric acid. Cadmium has been detected in some preparations of zinc.[1]

2. *Perchloride of tin*, $SnCl^2$, sold for the use of dyers under the name of *spirit of tin*, yields, with hydrosulphuric acid, a yellow precipitate, SnS^2, which is soluble, though with difficulty, in liquor ammoniæ, and is also soluble in concentrated hydrochloric acid.

3. A solution of *emetic tartar* ($KO,SbO^3,\bar{T}$) yields, with hydrosulphuric acid, an orange-red precipitate, SbS^3; which is soluble both in liquor ammoniæ and in hydrochloric acid. Dilute solutions of emetic tartar yield paler-coloured precipitates, somewhat resembling those produced in arsenical solutions.

If hydrosulphuric acid be transmitted through a liquid in which *pulvis antimonialis* has been boiled, the solution becomes of a reddish yellow colour (SbS^4).

Bihydrosulphate of ammonia, ($NH^3,2HS$) commonly called *hydrosulphuret of ammonia* (described at p. 451), is sometimes employed as a substitute for hydrosulphuric acid, an acid being added at the time of applying it, to neutralise the ammonia; but it is liable to several serious objections. When fresh prepared, it causes a yellowish precipitate with arsenious acid, red with emetic tartar, and black with solutions of lead; but by exposure to the air for a day or two, it forms a white precipitate with arsenious acid, yellow with emetic tartar, and red with lead!

Bihydrosulphate of ammonia occasions yellow precipitates with the salts of cadmium, bichloride of tin, and emetic tartar, without the addition of an acid, and therefore may be employed to distinguish these metallic salts from arsenious acid, which requires the addition of an acid to enable it to form a yellow precipitate with bihydrosulphate of ammonia.

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[1] Vide Thomson's *History of Chemistry*, ii. 220.

5. *Nascent hydrogen; Marsh's test.*—If arsenious acid be submitted to the action of nascent hydrogen, obtained by the action of zinc on diluted sulphuric acid, it is deoxidized, $AsO^3 + 6Zn + 6(HO,SO^3) = 6(ZnO,SO^3) + AsH^3 + 3HO$, and evolves arseniuretted hydrogen gas, AsH^3.—This gas is recognised by the following properties:—1, it has an alliaceous odour; 2, it burns with a bluish-white flame and the evolution of a white smoke (arsenious acid); 3, its flame deposits on a cold plate of glass, mica, or porcelain, held in the upper part of the flame, a black spot or ring surrounded by a larger white ring of arsenious acid; 4, if the gas be transmitted through a glass tube heated to dull redness, it is decomposed into its constituents, the metallic arsenic being deposited on the tube; 5, if arseniuretted hydrogen be transmitted through a solution of nitrate of silver, free nitric and. arsenious acids are formed in solution, while metallic silver is precipitated (see p. 651).

This test, which is the discovery of the late Mr. Marsh, of Woolwich,[1] may be thus applied:—Mix a small portion of the suspected liquid with some diluted sulphuric acid (1 part of *pure* oil of vitriol and 7 or 8 parts of water), and pour the mixture over some pieces of zinc previously introduced into a proper apparatus: bubbles of air immediately make their appearance. If no arsenious acid be present, the evolved gas is hydrogen; but if the liquor hold arsenic in solution, arseniuretted hydrogen gas is formed. Care must be taken not to apply a lighted taper to the jet of gas before the air is expelled, or an explosion may be the result. This gas is recognised by the before-mentioned characters, which, on account of their importance, require separate examination:—

α. It has an alliaceous odour.

β. It burns with a bluish-white flame and the evolution of a whitish smoke ($AsH^3 + 6O = AsO^3 + 3HO$). If a plate of mica (commonly termed talc) or of common window glass, or of porcelain (as a white saucer or dinner plate), be held a short distance above the flame, arsenious acid in a finely pulverulent state is deposited on it, forming a white crust: if the plate be depressed so as to cut the flame, and thereby slightly to impede the combustion of the gas, a blackish stain is also obtained; this in the centre is metallic arsenic, and in the circumference either the suboxide of arsenic, AsO [?], or the hydruret of arsenic, AsH^2. Around the black stain a white film of arsenious acid is deposited. Or both the black and white deposits may be readily and simultaneously procured by holding vertically over the flame a test tube or a tube of glass nine or ten inches long and a quarter or half an inch in diameter: the tube becomes lined for the space of several inches with metallic arsenic and arsenious acid, and the garlic odour can be detected at either end of the open tube. Or a small glass funnel may be substituted for the tube.

In order to prove that the white deposit is arsenious acid, and thereby that the gas was arseniuretted hydrogen, a solution of the arsenious acid should be obtained, and the liquid tests for this body applied to it. To obtain solutions of the acid, let the flame successively play beneath three or four drops of water placed separately on the under side of the plate of mica; then apply the liquid tests for arsenic before mentioned.[2] Or apply separate drops of the liquid

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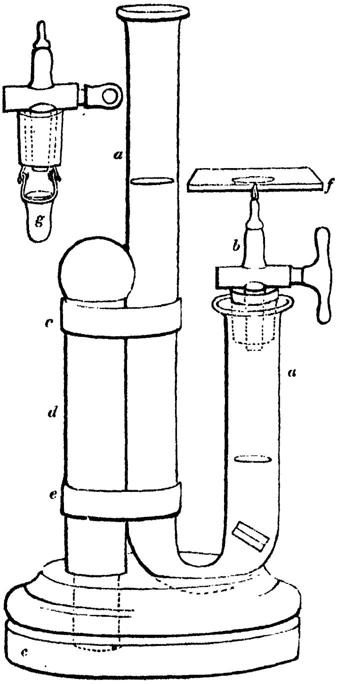
[1] *Transactions of the Society of Arts*, li. 66; also, *London Medical Gazette*, xviii. 650.

[2] Herapath, *London Medical Gazette*, vol. xviii. 889.

FIG. 122. FIG. 121.



Marsh's Apparatus.

FIG. 121.—*a*. A syphon tube. *b*. Stop-cock. *c*. Wooden block. *d*. The pillar. *e*, *e*. Caoutchouc slips, to fasten the tube to the pillar. *f*. Plate of mica or glass.
FIG. 122.—*g*. Small glass bucket.

tests themselves to the plate, and then let the flame play on them successively for a few minutes: the characteristic effects of arsenious acid will be obtained.

Various forms of apparatus may be used for this experiment. That employed by Mr. Marsh is a simple glass tube, bent like a syphon (fig. 121). A bit of glass rod is dropped into the shorter leg, then a piece of clean sheet zinc: the stop-cock and jet are afterwards to be inserted. The suspected liquid, mixed with the dilute acid before mentioned, is to be then poured into the long leg. Effervescence is then produced, and after allowing the air to be expelled, the stop-cock is to be closed; and when a sufficient accumulation of gas has taken place, it is again to be opened, and the gas ignited.

Where the matter to be examined was very small in quantity, Mr. Marsh put the suspected liquid, the acid, and the zinc, in a little glass bucket (fig. 122, *g*), attached to the stop-cock by a platinum wire, and then introduced it into the short leg of the syphon, previously filled with common water.

When the quantity of arsenical liquor to be tested is large, an inverted bell-glass with a stop-cock attached may be used. The zinc is suspended within. The bell-glass is immersed in the diluted acid to which the suspected liquor is added. This apparatus is similar to that used for obtaining fire by the aid of a stream of hydrogen gas thrown on spongy platinum.

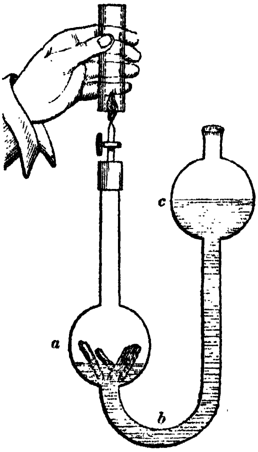
A modification (fig. 123) of Mr. Marsh's apparatus is supplied with two bulbs, one in each leg of the instrument, and presents some advantages over the simple syphon tube: thus it enables us to collect a larger quantity of gas, while the bulb assists in checking the frothing by breaking the bubbles.

But the simplest, cheapest, and often the most useful form of apparatus, is a two-ounce wide-mouthed phial, with a cork perforated by a glass tube or tobacco-pipe (as in fig. 124). It presents this great advantage, that we can employ a fresh apparatus for every experiment, and thus avoid all possibility of contamination from arsenical liquids used in previous experiments.

Dr. Letheby[1] has suggested some useful modifications in this apparatus. If an additional small bulb be blown between the stop-cock and the bulb *a*, fig. 123, it serves to break the bubbles or froth. Moreover, if the cross-piece *b* be doubly bent, thus ∿, it prevents the retrogression of the gas from the bulb *a* to the bulb *c*.

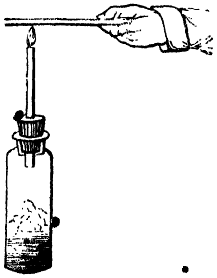
γ. If arseniuretted hydrogen be subjected to a red heat it is decomposed into

FIG. 123.



Modification of Marsh's Apparatus.

FIG. 124.



Simple mode of applying Marsh's Test.

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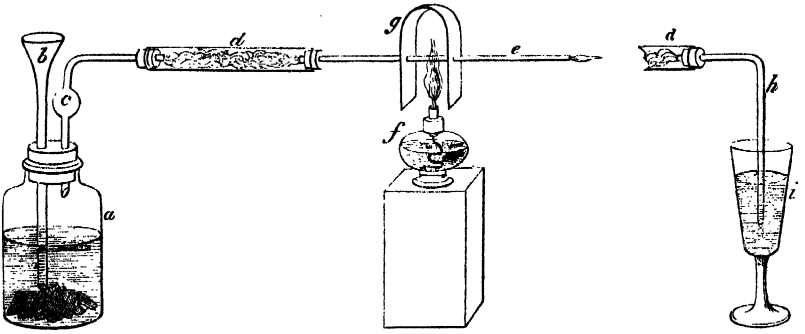
[1] *Pharm. Journ.* vol. v. p. 167, 1845.

arsenicum, which is deposited, and hydrogen gas, which escapes. The gas may be generated in a double-necked bottle, or in a wide-mouthed bottle, closed by a cork bored with two holes (fig. 125); and may be allowed to escape by a horizontal tube (made of difficultly fusible glass), which may be heated by a large-wicked spirit lamp. The gas is decomposed by the heat; and the arsenicum is deposited in the form of a metallic ring, beyond the flame and nearer the aperture.

Fig. 125.



Apparatus for subjecting Arseniuretted Hydrogen to the action of Heat or of Nitrate of Silver.

a. Bottle for generating the arseniuretted hydrogen.
b. Funnel, or tube, by which the sulphuric acid and arsenical liquor are introduced into the bottle.
c. Escape tube, supplied with a bulb, to condense any liquid which may rise from the bottle.
d. Wider tube, loosely filled with asbestos [or cotton wool] to impede the passage of any water. This is not essential.
e. Narrow tube of difficultly fusible glass, drawn out to a fine point at the extremity.
f. Spirit lamp.
g. Curved and perforated metallic plate (copper, zinc, or tinned iron), to support the glass-tube in the event of its softening by the heat.
h. Curved glass-tube, which may be substituted for the tube *e*, when the gas is to be passed through a solution of nitrate of silver.
i. Test-glass, containing a solution of nitrate of silver.

The detection of arseniuretted hydrogen by heat was suggested by Liebig,[1] Berzelius,[2] and Chevallier.[3] Some useful and practical improvements in the mode of applying this test were suggested by MM. Kœppelin and Kampmann.[4] The Commissioners appointed by the French Academy introduced some additional modifications of the experiment.[5] The latter recommend that the tube *e* should be coated with gold or silver leaf, and subjected to the heat of a coal fire, which is preferred to the spirit-lamp flame, as it more effectually decomposes the gas. But it complicates the operation, and renders it much more difficult of performance.

The arsenicum deposited in the tube may be recognized by its physical and chemical properties before described (see *ante*, pp. 638, 643, and 644).

If the arseniuretted hydrogen be completely decomposed, hydrogen only will be evolved by the extremity of the tube *e*. But as a portion of gas may escape decomposition, the jet should be set fire to, and attempts made to obtain arsenical spots on a plate of porcelain.

δ. If the arseniuretted hydrogen be passed through a solution of nitrate of silver, a mutual reaction between these substances is effected. Black metallic flocculi are deposited, and a solution of arsenious acid is obtained, mixed with free nitric acid, $6(AgO,NO^5)+AsH^3=6Ag+AsO^3+3HO+6NO^5$. Hydrochloric acid is then to be cautiously added to the decanted liquor, to convert the excess of nitrate of silver into the insoluble white chloride of silver. The filtered liquor may then be tested for arsenious acid. Or it may be evaporated to dryness, during which operation the nitric acid oxidizes the arsenious acid, and converts it into arsenic acid, AsO^5, which constitutes the dry residuum. This yields a brick-red precipitate, $3AgO,AsO^5$, with a solution of nitrate of silver. Or the concentrated solution may be transferred to Marsh's apparatus.

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[1] *Journal de Pharmacie*, t. xxiii. p. 568.
[2] *Ibid.* t. xxiv. p. 180.
[3] *Journ. de Chim. Méd.* t. v. 2e Sér. p. 380.
[4] *Journ. de Pharmacie*, t. xxvii. p. 480; *Lond. Med. Gaz.* Aug. 20, 1841.
[5] *Ibid.* t. xxvii. p. 425.

This test was suggested by Lassaigne.[1] It has been adopted by the Commissioners appointed by the French Academy.[2] It is a very valuable mode of using Marsh's test, and prevents the loss of the first portions of gas.

The apparatus fitted for performing Lassaigne's test has been already described and figured (see *ante*, p. 650, fig. 125, *h*).

The black flocculi produced in a solution of nitrate of silver by arseniuretted hydrogen are regarded by Lassaigne as metallic silver, by Graham[3] as arseniuret of silver. It appears to me to be metallic silver contaminated by some intimately adherent arsenious acid, which can be removed by repeated washing and boiling in water, and especially by washing with an alkaline solution.

In the performance of Marsh's test there are several impediments and fallacies, with which the student should be acquainted.

a. The *impediments* to the operation of Marsh's test are, organic liquids (as porter, soup, contents of the stomach, &c.), which occasion great frothing, and choke up the jet. To obviate this, various methods have been advised; such as greasing or oiling the interior of the short leg of the apparatus; putting a layer of alcohol or oil on the surface of the liquid in the short limb, and placing the apparatus aside for an hour or two, to allow the bubbles to burst. These methods are all more or less objectionable. They either imperfectly fulfil the object intended, or they mask somewhat the qualities of the arseniuretted hydrogen.

The best mode of proceeding in these cases is to remove the arsenic from the liquid by Reinsch's process hereafter noticed (see p. 652). But if it be thought desirable to get rid of the organic matter, the arsenical liquor should be evaporated to dryness, and charred either by heat, very cautiously applied, or by means of oil of vitriol. Danger and Flandin[4] give the following directions for its execution:—Add to the organic matter contained in a porcelain capsule, ⅙ of its weight of sulphuric acid, and heat until vapours of sulphuric acid appear. The matter is first dissolved, but during the concentration it is charred. The liquor is to be constantly stirred with a glass rod. The carbonization is effected without any swelling or frothing, and is to be continued until the charcoal is friable and almost dry. A small quantity of concentrated nitric acid or nitro-muriatic acid is to be added, by means of a pipette, when the capsule is cold. This converts the arsenious acid into the more soluble arsenic acid. The mixture is then to be evaporated to dryness, treated with boiling water, and the limpid liquor introduced into Marsh's apparatus, in which it never froths.

Nitric acid or nitrate of potash is sometimes used to char organic matter; but it is less manageable than sulphuric acid; for towards the end of the experiment it is difficult to prevent deflagration, by which part of the arsenic is lost.

β. The *fallacies* of this test arise from the presence of either antimony or imperfectly charred organic matter in the suspected liquid, or from the employment of either zinc or sulphuric acid contaminated with arsenic. A solution of emetic tartar ($KO,SbO^3,\bar{T}$) placed in Marsh's apparatus (with zinc and dilute sulphuric acid), evolves *antimoniuretted hydrogen gas* (SbH^3). The oxide of antimony, contained in the emetic tartar undergoes deoxidation, $KO,SbO^3,\overline{T}+6Zn+6(HO,SO^3)=KO,\overline{T}+6(ZnO,SO^3)+SbH^3+3HO$. Antimoniuretted hydrogen agrees in several of its characters with arseniuretted hydrogen.[5] Thus it has a peculiar odour which might be mistaken for that of arseniuretted hydrogen, though it is not alliaceous. It burns in the air with a pale bluish-green flame, and the deposition (on mica, glass, or porcelain) of a black stain (metallic antimony?), which is surrounded by a white one of oxide of antimony (SbO^3). Moreover, the action of hydrosulphuric acid and of ammonio-sulphate of copper on the oxide of antimony, produces colours similar to those generated by the action of these tests on arsenious acid. Furthermore, when heated during its passage through a glass tube, antimoniuretted hydrogen is decomposed, and deposits a dark metallic crust. It also occasions a black deposit of antimoniuret of silver in a solution of nitrate of silver, $3(AgO,NO^5)+SbH^3=Ag^3Sb+3NO^5+3HO$.

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[1] *Journal de Chimie Méd.* t. vii. 2e Sér. p. 638.

[2] *Journal de Pharmacie*, t. xxvii. p. 425; also, *Lond. Med. Gaz.* Aug. 20, 1841.

[3] *Elements of Chemistry*, p. 635.

[4] *Journal de Pharmacie*, t. xxvii. p. 411-412.

[5] Mr. L. Thomson, *Lond. and Edinb. Phil. Magazine*, May 1837; also Pfaff, *Pharmaceutisches Central-Blatt für* 1838, S. 65.

The antimonial is distinguished from the arsenical crust by the following characters:—First, the dark stain is less bright and metallic than the arsenical one, and, when viewed by transmitted light, is smoky black; whereas that of arsenic is hair-brown. Secondly, if the flame be allowed to play on a solution of ammonio-nitrate of silver, placed on the under surface of a plate of mica, no yellow arsenite of silver is obtained. Thirdly, the greater volatility of arsenicum, and its conversion into octohedral crystals of arsenious acid,[1] may serve, in some cases, to distinguish it from antimony. Fourthly, the solubility of arsenious acid, and the reaction of the before-mentioned liquid tests on the solution, will distinguish it from oxide of antimony, which is insoluble. Fifthly, if antimoniuretted hydrogen be conveyed into a solution of nitrate of silver, no arsenious or arsenic acid can be detected by the tests before directed to be used for arseniuretted hydrogen. Lastly, the metallic crust obtained by submitting a current of the gas to heat presents some distinguishing characters: the arsenical crust is always deposited in the more distant or anterior part of the tube; whereas the antimonial one is first deposited on the heated part of the tube, and by continuing the heat we obtain two rings—one in the anterior or more distant, the other in the posterior or less distant, part of the tube.

In performing Marsh's test, great care must be taken that the apparatus be perfectly clean, and that fresh zinc and acid liquor be used for every experiment. It has been already stated (see *ante*, p. 356), that sulphuric acid frequently contains arsenious acid. The experimenter should also be fully aware of the possibility of the zinc, or even the brass-work of the apparatus, containing minute traces of arsenic; hence the necessity of examining the qualities of the hydrogen flame before adding the suspected arsenical liquid. It has been shown by Mohr[2] that zinc which had been once used, but afterwards carefully washed both in water and acid, retained sufficient arsenic to produce the usual effects on the hydrogen flame.

Messrs. Danger and Flandin[3] have asserted, and their statements are confirmed by the report of the commissioners of the French Academy,[4] that imperfectly carbonised organic matter introduced into Marsh's apparatus, may deposit on glass, or porcelain, crusts which strongly simulate those obtained from arsenical substances. These non-arsenical spots are composed of sulphite and phosphite of ammonia mixed with a small quantity of organic matter. They dissolve with difficulty in nitric acid; and the residue, obtained by evaporating the nitric solution to dryness, yields, on the addition of nitrate of silver, a yellow precipitate of phosphate of silver. The true arsenical spots, on the other hand, dissolve readily in nitric acid; and the residue obtained by evaporating the nitric solution to dryness forms, with nitrate of silver, a brick-red precipitate of arseniate of silver.

6. *Reinsch's process.*—This test was proposed by Reinsch.[5] If an aqueous solution of arsenious acid be boiled with pure hydrochloric acid and clean copper foil, or fine copper gauze, or copper wire, the latter acquires an iron-grey metallic coating of metallic arsenic. $AsO^3+3Cu=As+3CuO$. If the coated copper be washed, dried, cut into small pieces, and then heated in a glass tube by the flame of a spirit lamp, the metallic arsenic is volatilized, and sometimes yields a metallic ring; but in general it becomes oxidized, and yields a sublimate of minute octohedral crystals (AsO^3). If the coating be sufficiently

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[1] Dr. E. Turner's *Chemistry*, by W. Turner.

[2] *Journ. de Pharm.* t. xxiii. p. 563.

[3] *Ibid.* t. xxvii. p. 410.

[4] *Ibid.* p. 428.

[5] *Journ. für praktischen Chimie*, Bd. xxiv. S. 242, 1842.

thick, it may be scraped from the copper and heated alone in the tube. The obtained arsenious acid should be dissolved in water and tested with ammonio-nitrate of silver and hydrosulphuric acid (see *ante*, pp. 645 and 646). Moreover, the solution may be introduced into Marsh's apparatus, and the evolved gas tested as before directed (see *ante*, p. 648).

Dr. Christison recommends that the arsenical solution be mixed with one-tenth of its volume of hydrochloric acid: Dr. Taylor employs one-sixth part. The copper may be obtained of any required thinness by the action of dilute nitric acid. The time required for the ebullition will vary according to the strength of the arsenical solution. When this is weak, the boiling should be continued for at least a quarter of an hour.

In conducting this test, care must be taken that the hydrochloric acid be free from arsenic. This may be readily ascertained by boiling it with water and clean copper prior to the addition of the suspected liquor.

Reinsch's process is valuable rather as yielding a ready means of abstracting arsenic from its solution, than as furnishing a new character or test for this substance.

When the quantity of arsenious acid contained in the liquor is very small, some difficulty may be found in effecting its complete separation from the copper in the form of a distinctly recognizable sublimate. This certainly forms a *drawback* to the use of Reinsch's process.

The *fallacies* of Reinsch's process are, that many liquids will communicate a stain to copper, and some even will cause the formation of a metallic coating. In all cases, therefore, the proof of the presence of arsenic must depend, not on the mere production of a stain or metallic coating, but on the subsequent conversion of this coating into arsenious acid, which must be recognised by the characters before-mentioned.

Solutions of mercury and silver yield metallic deposits without boiling. Those of tin and lead tarnish the copper, but yield no decided metallic deposit (Dr. Alfred Taylor). Bismuth and antimony are the metals whose solutions yield metallic deposits, by Reinsch's process, which most closely resemble that produced by arsenic. "There is one answer to all of these objections; namely, that, from the arsenical deposit, octohedral crystals of arsenious acid may be procured by *slowly* heating the slip of copper, or the grey deposit from it, in the reduction tube. . . . . If a deposit take place on copper, but arsenious acid cannot be obtained by heating it, then the evidence of its having been arsenic is defective."[1]

Dr. Letheby[2] has proposed to substitute zinc for copper, and nitric acid for hydrochloric acid. The metallic arsenic is thrown down on the zinc, which, when mixed with water and sulphuric acid, and placed in Marsh's apparatus, evolves arseniuretted hydrogen.

γ. Detection of Arsenious Acid contained in, or mixed with, Organic Substances.—I shall confine myself to a brief notice of the modes of detecting arsenious acid when mixed with, or contained in, organic substances, such as articles of food, the contents of the gastro-intestinal tube, the viscera (especially the stomach and liver), the muscles, the urine, &c. For further details the reader is referred to the valuable works on toxicology of Drs. Christison and Alfred Taylor.

When arsenic is swallowed, it becomes absorbed into the blood, circulates through the body, contaminates the various tissues, and is ultimately eliminated (should the patient survive) by the kidneys. Hence, in toxicological investigations, it becomes necessary to submit to examination, not only the solids or liquids in which the poison is suspected to have been administered, and the contents of the stomach and bowels, but also the stomach itself, the liver, the muscles and other animal tissues, the blood, and the urine.

In some cases arsenious acid in the solid state may be readily detected in organic mixtures, and may be picked out or separated by mechanical means. When the stomachs of persons poisoned by this acid are laid open, we sometimes observe the poison in the form of a white powder or white particles or lumps: these are, of course, to be carefully removed, and if they be arsenious acid, no difficulty will be experienced in recognizing them by the tests already mentioned (see *ante*, pp. 642 and 643). I on one occasion found about four drachms of solid arsenious acid, in small lumps, in the stomach of a gentleman poisoned by this substance.

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[1] Dr. Alfred Taylor, *On Poisons*, p. 353-54.

[2] *Pharmaceutical Journal*, vol. v. p. 165, 1845.

When the arsenic is contained in solution, the liquid should be separated from insoluble matters, with which it may be mixed, by filtration through a hair sieve, muslin, cotton, or paper. Oil may be separated from the aqueous liquid by passing the latter through a coarse paper filter previously moistened with water.

Different methods of detecting arsenic in organic mixtures have been recommended by different writers. It may be said that each has its advantages in particular cases. I shall notice three methods:—

1. *Reinsch's process.*—Arsenic is frequently and with facility extracted from organic mixtures by Reinsch's process. The method of proceeding for simple arsenical liquids has been already described (see *ante*, p. 652). If it be required to extract, by this process, arsenic from solid organic substances (as the stomach, liver, &c.), cut the soft solids into small fragments, and boil them with water acidulated with about one-tenth of hydrochloric acid, until the tissues are all dissolved or broken down into fine flakes or grains. Filter through calico, heat again to the boiling point, and proceed by Reinsch's process as before described.

2. *Marsh's process.*—The difficulty of detecting arsenic in organic liquids by Marsh's process arises from the frothing. Danger and Flandin's method of obviating this has been before described (see *ante*, p. 651.) Their process is also applicable to solid organic substances containing arsenic.

3. *Process by hydrosulphuric acid.*—In some cases arsenious acid may be conveniently separated from an organic liquid by passing a stream of hydrosulphuric acid through the liquid previously acidified by hydrochloric acid (see *ante*, p. 646), by which a yellow precipitate of orpiment is obtained. This is then to be reduced by the soda-flux (see *ante*, p. 644.) Organic solids should be cut to pieces, boiled with distilled water, the decoction, when cold, filtered, then acidified with acetic acid, again filtered, evaporated to dryness, re-dissolved in distilled water, and the solution filtered and acidified (if not acid) with hydrochloric acid: sulphuretted hydrogen is then to be transmitted through the liquid. This process is inferior to either of the two preceding ones.

Composition.—The following is the composition of arsenious acid:—

	Atoms.	*Eq. Wt.*	*Per Cent.*	*Berzelius.*	*Mitscherlich.*
Arsenicum	1	75	75·76	75·782	75·73
Oxygen	3	24	24·24	24·218	24·27
Arsenious Acid	1	99	100·00	100·000	100·00

Purity.—Powdered arsenious acid is sometimes adulterated with chalk or sulphate of lime. The fraud is readily detected by heat, which volatilizes the acid, but leaves the impurities.

It is entirely sublimed when heated. Mixed with charcoal and exposed to heat, it emits an alliaceous smell. It is dissolved by boiling water; and hydrosulphuric acid, when added, throws down a yellow precipitate, and lime-water yields a white one.—*Ph. L.*

The *Edinburgh College* merely observes, that arsenious acid "is entirely sublimed by heat."

PHYSIOLOGICAL EFFECTS. *a. On Vegetables.*—The effects of arsenious acid on plants have been studied by Jäger,[1] Marcet, Macaire,[2] and by others, and from their observations we learn that it is poisonous to all the higher, and most of the lower, families of plants. It appears that seeds which have been soaked in a solution of arsenious acid are incapable of germinating, and that buds which have been plunged in it are no longer capable of expanding. If roots or stems be immersed in this solution, the plants perish; death being preceded by drooping of the leaves and petals, and the appearance of brownish patches on the leaves, the veins and midribs of which are discoloured. If the stem of the Common Barberry (*Berberis vulgaris*) be placed in a solution of arsenious acid, the plant dies, but the stamens, according to Macaire, become stiff, hard, and retracted, and on any attempts being made to alter their position, they readily break. On repeating the experiment, however, I did not observe this condition of the stamens. I found them not at all brittle, but quite flexible, and difficult to break by the point of a knife. The leaves, when burnt, evolved a garlic odour.

Jäger also found that arsenic is absorbed by plants; for, on burning vegetables destroyed by this poison, he experienced, as I have done, an alliaceous odour.

On some cryptogamic plants arsenious acid appears to have no injurious influence. Jäger has seen a small plant (supposed by De Candolle[3] to be *Mucor imperceptibilis*) growing in water which contained $\frac{1}{32}$ of its weight of arsenic. And, more recently, Gilgenkrantz[4] says he has seen an algaceous plant, of the genus either *Leptomitus* or *Hygrocrocis*, develope itself in a solution of arsenic. I can confirm his statement. I have at this moment before me an abundant vegetation (*Hygrocrocis?*) in a solution of arsenious acid, the vegetable filaments being intermixed with octohedral crystals of arsenic. These are most remarkable exceptions to the general effects of this poison on vegetables, and deserve further examination.

β. On Animals generally.—Arsenious acid is poisonous to all classes of animals. No exceptions, I believe, are known to exist to this statement. The most extensive series of experiments on this subject are those performed by Jäger.[5] From them we learn, that in all animals, from the infusoria up to man, death from arsenic is invariably preceded by inordinate actions and increased evacuations, especially from the mucous membranes. In most animals the stools were frequent and fluid; and in those in which mucus is secreted on the surface, it was remarkably increased. The power of voluntary motion and susceptibility of external stimuli were decreased; and after death the muscles soon ceased to be influenced by the galvanic agency. In animals which breathe by lungs, respiration became difficult and laborious; and in warm-blooded animals great thirst was experienced. In birds and mammals convulsions came on, preceded by vomiting, except in those animals (as the rabbit) which cannot vomit (see *ante*, p. 85). Enormous quantities of arsenious acid have been sometimes administered to horses with impunity. Berthe[1] gave two, and afterwards three, drachms to a mare, for the cure of an obstinate skin disease, without any injurious effects. Beissenhirz[2] gave successively, on different days, one, four, three, two, and eight drachms of arsenious acid to a horse: the animal did not die until the ninth day after taking the last-mentioned dose. Yet, notwithstanding these and some other analogous facts, which seem to prove that arsenic has comparatively little effect on horses, the best-informed veterinarians agree in considering it an energetic poison to these animals.[3]

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[1] *Diss. Inaug.* Tubingæ, 1808; quoted by Marx, in his *Die Lehre von den Giften*, ii. 99.

[2] *Mém. de la Soc. de Phys. et d'Hist. Nat. Genève*, t. iii.

[3] *Phys. Vég.* p. 1329.

[4] *Journ. de Pharm.* xxiii. 38.

[5] *Op. cit.*

γ. *On Man.* αα. *Of very small or therapeutical doses.*—In very small quantities (as one-sixteenth or one-twelfth of a grain) no obvious effects are usually produced by the use of arsenic, unless it be continued for a long period. Indeed some writers[4] go so far as to assert that it is a strengthening remedy, and that it improves the appetite, invigorates digestion, promotes assimilation and secretion, excites the muscular and nervous functions,—in a word, acts as a *tonic*. I cannot, however, subscribe to this doctrine. It is, indeed, true that patients sometimes experience a temporary increase of appetite from the use of small doses of arsenic; and it is also certain that this remedy is frequently beneficial in agues and other diseases in which tonics have been found efficacious. But the analogy between the action of arsenious acid and that of the vegetable tonics, as cinchona (to which Vogt compares it), stops here. I have sought in vain for other evidences of a tonic operation. I have seen very minute doses of arsenic given to patients affected with lepra, and continued for many days, without being able to detect the least indication of its action on the system, except the amelioration of the disease. When the dose was slightly increased, the appetite in some cases appeared to be increased; but the effect was neither universal nor continued. Very shortly afterwards, a sensation of heat in the throat, œsophagus, and stomach, came on, occasionally with nausea, but seldom with vomiting; in a few cases with gastrodynia; a febrile condition of the body was set up; there were dryness of the skin, increased secretion of urine, relaxed bowels, sometimes with griping; the patients usually complain of great languor, inaptitude for employment, and want of sleep; and sometimes these symptoms were accompanied with, or followed by pricking or irritation of the tarsi, redness of the eyes, a slight degree of conjunctivitis, and certain swellings, especially of the face (*œdema arsenicalis*)—effects which are so different from those produced by the remedies called strengthening, that I cannot regard arsenic as a tonic. In proof of the beneficial effects of this substance, we are gravely told that the country-people of Upper Styria, in Austria, use arsenic as a stomachic and condiment for many kinds of food—for example, cheese; and a healthy peasant himself tells us, that he was accustomed to take two grains of arsenic daily, without which, he assures us, he could not live![5] In further proof of this strengthening action of arsenic, Vogt says that it promotes the appetite, the activity, and the power of old enfeebled horses, and mentions that Jäger noticed the same effects on a pigeon. To the first of these statements, namely, the beneficial effects from the use of arsenic as a condiment, I do not give credence; and, with respect to the action of arsenic on horses, every well-informed veterinarian knows that this substance operates on these animals as a poison.

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[1] *Recueil de Méd. Vét.* Oct. 1825.

[2] Quoted by Wibmer, *Die Wirkung*, &c. i. 317.

[3] See the evidence of Mr. Bowles, in the *Edinb. Med. and Surg. Journ.* viii. 351.

[4] Vogt, *Pharmakodynamik.*

[5] *Med. Jahrb. d. Österr. Staates*, 1822, i. 96, quoted from Wibmer.

Dr. Fowler[1] gives the following summary of the effects of the arsenical solution in more than 320 cases:—In about one third no operation: "somewhat more than one third were attended with nausea; and nearly one-third with an open body; and about one-third with griping. Vomiting, purgings, swellings, and anorexia, were but rare in comparison with the preceding effects, and their less frequent occurrence was generally found in the order in which they are here enumerated, swellings and anorexia being the seldomest. About one-fifth of the cases attended with nausea, and one-quarter of those attended with an open body, were unconnected with any other effects. Griping did not often occur alone; purging and anorexia seldom or never; and vomiting was always accompanied with more or less nausea."

There are several effects produced by medicinal doses of arsenic which Dr. Fowler has overlooked. The most important of these are the irritation of the conjunctiva and swelling of the face. As soon as these occur the arsenic should be either suspended or given in reduced doses. Mr. Hunt[2] states that in persons of fair complexion and delicate skin, arsenic commonly produces a dirt-brown, dingy, unwashed appearance of all those parts of the body protected from the access of light and air. He says that when examined under a lens there is found to exist a delicate desquamation of the skin; in fact, a faint form of pityriasis. In some cases salivation has been produced by the medicinal use of arsenic, as will be noticed presently.

β. *Of long-continued small doses, or of large medicinal doses* (*slow or chronic poisoning*).—Small doses of arsenious acid continued for a long period, act as a slow poison; and, if persevered in, will ultimately occasion death. The same effects take place, in a shorter period, from the administration of large medicinal doses. Sometimes the digestive apparatus, at other times the nervous system, first shews symptoms of the poisonous operation of this agent.

Hahnemann (quoted by Dr. Christison) has graphically described the condition of slow poisoning by arsenic as "a gradual sinking of the powers of life, without any violent symptom; a nameless feeling of illness, failure of the strength, an aversion to food and drink, and all the other enjoyments of life."

On some occasions the first symptoms which I have observed of its poisonous operation have been thirst, redness of the conjunctiva and eyelids, followed by a cutaneous eruption. At other times irritation of the stomach is the leading symptom. In some cases ptyalism is brought on. Marcus[3] noticed this effect; as also Dr. Ferriar.[4] Mr. Furley[5] has published five illustrative cases of it. Trousseau and Pidoux[6] also mention this symptom as produced by the long-continued use of feeble doses of arsenic. Another instance of this effect has been published by Mr. Jones.[1] This effect acquired some importance in the celebrated Bristol case of poisoning.[2]

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[1] *Med. Reports of the Effects of Arsenic*, p. 98, Lond. 1786.

[2] *Practical Observations on the Pathology and Treatment of certain Diseases of the Skin generally pronounced Intractable*, p. 15, Lond. 1847.

[3] *Ephemeriden*, 1809.

[4] *Med. Hist. and Refl.* iii. 306.

[5] *Lond. Med. Gaz.* xvi.

[6] *Traité de Thérap.* ii. 148.

The following is an abstract of the symptoms produced by the long-continued employment of small doses of arsenious acid, but which are more or less modified in different cases:—Disorder of the digestive functions, characterised by flatulence, sensation of warmth, or actual pain, in the stomach and bowels; loss of appetite; thirst, nausea, and vomiting; purging, or at least a relaxed condition of the bowels, and griping; furred tongue, with dryness and tightness of the mouth and throat, or with salivation. Quick, small, and sometimes irregular, pulse; oppressed respiration, with a dry cough. The body wastes; the stomach being frequently so irritable that no food can be retained in it. Headache, giddiness, and want of sleep, are frequently observed. The limbs become painful, feeble, trembling, subject to convulsions; occasionally benumbed, and ultimately paralysed. The cutaneous system is, in some cases, affected, an eruption makes its appearance, and now and then the hair and nails fall off. Swelling of the feet and of the face is not unfrequently observed; and under these symptoms the patient gradually sinks, in some cases retaining his consciousness to the last, but at other times delirium or stupor supervening.

γ. *Of excessive or poisonous doses (acute poisoning).*—The symptoms produced by the ingestion of a large dose of arsenious acid are not invariably alike, but put on three forms. In some cases the principal or leading ones are those indicating gastro-enteritis; the nervous system being not obviously, or at least only slightly, affected. In others, the gastro-enteritic symptoms are absent, and the principal operation of the poison is on the vascular and nervous systems. Lastly, there are other cases in which we have gastro-enteritic symptoms, with an affection of the nervous and vascular systems.

Form 1st: Acute poisoning with symptoms of gastro-enteritis.—In this form of arsenical poisoning, nausea and vomiting come on soon after the poison has been swallowed, and are attended with burning pain in the throat and stomach, which soon extends over the whole abdomen. Pain and vomiting, however, are not invariably present. The matters vomited vary in their nature and appearance; sometimes being bilious, at other times tinged with blood. Frequently there is a sense of heat, dryness, tightness, and constriction of the throat, accompanied with incessant thirst, and occasionally with an almost hydrophobic difficulty of swallowing. The lower part of the alimentary canal soon becomes affected, indicated by the burning pain, which is increased on pressure,—by the hard and tense condition of the abdomen, by the diarrhœa (the stools occasionally being bloody), by the tenesmus, and by the occasional heat and excoriation of the anus. When the lower part of the alimentary canal is powerfully irritated, the urino-genital apparatus becomes affected; and thus there may be difficulty in passing the water, with burning pain in the genital organs. The urine is frequently diminished, and sometimes suppressed. The constitutional symptoms are, in part, such as might be expected from this violent local disorder: thus the pulse is quick, but at the same time small, feeble, and irregular; there are cold clammy sweats; the action of the heart is irregular, giving rise to palpitation; the breathing is short, laborious, and often painful; the tongue is dry and furred; and the membrane lining the air-passages feels hot, and oftentimes painful.

Although, in this form of acute arsenical poisoning, the gastro-enteritis is the principal, and, in some cases, almost the only affection, yet there are generally observed some symptoms indicative of disorder of the cerebro-spinal system: sometimes in the form of tremblings or cramps of the limbs, or delirium, and even, in the last stage, insensibility. Occasionally, also, eruptions take place.

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[1] *Lond. Med. Gaz.* xxvi. 266.

[2] *Ibid.* xv. 519; and *Trans. Prov. Assoc.* iii. 432.

In this form of poisoning, death usually occurs in from twenty-four hours to three days after the administration of arsenic; but Dr. Christison says that Pyl has recorded a case where death occurred in three hours after swallowing the poison.

Form 2d: Acute poisoning with collapse or narcotism, without any remarkable symptoms of gastro-enteritis.—In some cases of poisoning, in both man and animals, the symptoms are those indicating disorder of the cerebro-spinal and vascular systems: abdominal pain, vomiting, and purging, being either altogether absent or very slight. The symptoms are usually faintness, or perhaps actual syncope, frequently convulsions, or paralysis; and, sometimes, insensibility or delirium. This form of arsenical poisoning is somewhat rare. In most of the recorded cases the quantity of arsenious acid taken was very large; for example, half an ounce, or even more.

I have seen one case of this form of poisoning. The individual (a gentleman about 20 years of age) coarsely pounded a lump of arsenious acid, and swallowed it. At a rough calculation, it was supposed that he took six or eight drachms of the poison. The symptoms were pain, vomiting, great weakness with extreme depression of the vascular system, faintness, collapse, and death in about four hours. His intellect was clear until a very short time before death, when he sank into a dose. There were neither convulsions nor paralysis. Every attempt was made to remove the poison from the stomach; copious vomiting existed; large draughts of water were administered, and the stomach-pump was applied. Notwithstanding these circumstances, I found more than four drachms of solid arsenious acid, in the form of lumps, in the stomach after death. Their weight had apparently prevented their removal during life.

Form 3d: Acute poisoning with symptoms of gastro-enteritis, followed by an affection of the cerebro-spinal system.—In this form of poisoning we have at first the usual gastro-enteritic symptoms, and which I have already described under the first form of poisoning. When, from the smallness of the dose, or from other circumstances, the patient recovers from the gastro-enteritis, symptoms of a cerebro-spinal affection sometimes make their appearance. The kind of disorder, however, varies considerably in different individuals. "The most formidable," says Dr. Christison, "is coma; the slightest, a peculiar imperfect palsy of the arms or legs, resembling what is occasioned by the poison of lead; and between these extremes have been observed epileptic fits, or tetanus, or an affection resembling hysteria, or madness."

In a medico-legal point of view it is important to determine *what is the smallest fatal dose of arsenious acid.*[1] It is not easy, however, to give a positive answer to this question. Dr. Christison says, "the smallest actually fatal dose I have hitherto found recorded is 4½ grains. The subject was a child four years old, and death occurred in six hours. In this instance, however, the poison was taken in solution." Dr. Letheby[2] has reported a case in which two grains and a half proved fatal in 36 hours: the patient was a robust girl. More recently a case has been recorded[3] in which there was reason to suspect that the death of a woman was produced by half an ounce of Fowler's mineral solution (=2 grs. of arsenious acid). The powerful effects sometimes produced by $\frac{1}{8}$, $\frac{1}{4}$, or $\frac{1}{2}$ a grain, lead us to suspect that one grain *might* produce death; but we have no recorded case of this. Hahnemann says, one or two grains may prove fatal in a few days; and Dr. Christison remarks that this statement cannot be very wide of the truth. Of course a *repetition* of much smaller quantities might cause death. Dr. Alfred Taylor considers that from two to three grains may be regarded as a fatal dose. However, under certain circumstances, enormous quantities have been swallowed with very trivial effects. Some years ago I opened the body of a man who destroyed himself by taking arsenic, and I was informed by the friends that about a fortnight previous to his death he made an attempt to destroy himself by swallowing a quantity of powdered arsenic, which they found, on inquiry at the druggist's of whom it was purchased, to have weighed half an ounce. It was taken immediately after dinner, and the only effect produced was violent vomiting. Here it is evident that the distension of the stomach with food saved the patient's life. This unfortunate individual repeated the attempt, and death was the result. Another remarkable case of recovery, after the ingestion of half an ounce, has been recorded by Dr. Skillman.[1]

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[1] See some remarks on this subject by Mr. A. S. Taylor, in the *Guy's Hospital Reports*, No. xii.; also in his work *On Poisons.*

[2] *Lond. Med. Gaz.* vol. xxxix. p. 116, Jan. 15, 1847.

[3] *Ibid.* vol. xlii. p. 87, July 14, 1848.

MORBID APPEARANCES PRODUCED BY ARSENIOUS ACID.—When arsenious acid kills by its narcotic operation (constituting the second form of arsenical poisoning), no morbid condition is observable after death. In other cases, however, various alterations are observed, which may be most conveniently arranged under the following heads:—

a. Morbid appearances of the alimentary canal.—The alterations observed in the condition of the intestinal canal vary with the quantity of the poison taken, and probably with other circumstances, but they are all indicative of inflammation: thus we have redness as one symptom, sometimes accompanied with extravasations of blood into the tissue of the canal; ulceration is also frequently observed, sometimes softening of the mucous coat, effusion (of lymph or blood), and occasionally even gangrenous spots.

β. Morbid appearances of the vascular system.—The blood is sometimes, though not invariably, fluid after death, and dark coloured. The heart is mostly flabby, and it is asserted that on its inner surface (especially the carneæ columnæ and valves, particularly of the left side), is observed redness, sometimes diffused, sometimes in the form of spots,[2] which penetrate a line in depth into the substance of the heart. The pericardium usually contains serum.

γ. Morbid appearances of the respiratory system.—These are neither very remarkable nor constant, and principally consist in redness of the pleura, effusion of lymph or serum into the cavity of the pleura, red spots, and occasional congestion of the lungs, and redness of the membrane lining the air-tubes.

δ. The *morbid appearances of other parts* deserve little attention. In some cases, inflammation, and even gangrene, of the *genital* organs have been observed; the *conjunctiva* is sometimes very vascular, and alterations are occasionally observed in the condition of the *skin.* Redness, extravasation of blood, and effusion of serum, are said to have been seen in the *brain.*

In connection with the morbid appearances produced by arsenic, the following remarks, made by Orfila,[3] deserve notice:—Under certain circumstances, the mucous membrane of the stomach and intestines is lined with a multitude of brilliant points, composed of fat and albumen: placed on burning coals, these grains decrepitate on drying, and produce a noise which has been improperly denominated *detonation:* they inflame as a fatty body when they contain a notable quantity of fat, and exhale an odour of burned animal matter. These *fatty* and *albuminous* globules may be met within the bodies of individuals who have not been poisoned, and require attentive examination in order to distinguish them from arsenious acid. The best method of avoiding this error is to digest these granular parts with water, and to apply the tests proper for demonstrating the existence of arsenious acid."

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[1] *Lond. Med. Gaz.* vol. xix. p. 238, from *American Journ. of Med. Sciences,* Aug. 1836.

[2] White spots are frequently met with on the surface of the heart when no arsenic has been taken (*Guy's Hospital Reports,* vol. iii.)

[3] *Dict. de Méd.* éd. 2, art. *Arsenic.*

Influence of Arsenious Acid on the Putrefactive Process.—Until the commencement of the present century it was supposed that the bodies of animals poisoned by arsenious acid were unusually prone to putrefaction. This, however, has been satisfactorily disproved by the experiments and observations of Klank, Kelch, Hünefield, and others;[1] and it appears that, when placed in contact with animal textures, it acts as an antiseptic. "I have kept a bit of ox's stomach four years in a solution of arsenic," says Dr. Christison, "and, except slight shrivelling and whitening, I could not observe any change produced in it." This antiseptic property of arsenious acid, which has been, in my opinion, fully and satisfactorily proved, sufficiently accounts for the good state of preservation in which the alimentary canal has been frequently found some months after death in those poisoned by this acid, where it was not evacuated by vomiting or purging.[2]

But there is another effect said to be produced on the bodies of animals, which is not so easily accounted for: I mean their conversion into a kind of mummy-like or adipocerous matter. The following is an abstract of the phenomena, as deduced from numerous experiments and observations, several of which are recorded in Dr. Christison's invaluable *Treatise on Poisons*. After death putrefaction commences, and is attended with the usual odour; but, instead of increasing in the customary manner, it seems for a time to be at a stand-still, and then a series of changes commences of a peculiar character: the soft parts become firmer and drier, at the same time retaining their structure; the putrid odour is frequently succeeded by one resembling garlic; the skin becomes brown and parchment-like; the muscular fibres and cellular tissues (especially of the abdominal parietes) are changed into a tallowy cheesy-like mass; the liver, spleen, and heart, become dry, while the bowels, lungs, and brain, form a greasy mass. During these processes the quantity of arsenic in the body diminishes, probably by exhalation,—a circumstance very probable, when we bear in mind the garlic odour emitted by the body, and which has been observed by several writers. The diminution, however, must be exceedingly small. After some time the cheesy smell disappears, and the body becomes dry and hard. In some cases the alimentary tube has been found little changed or decomposed, although other parts of the body had been completely mummified.

I ought, however, to remark, that some writers do not ascribe these phenomena to the influence of arsenious acid, but to other causes. Jager[3] tells us that in his experiments the putrefaction of the bodies of animals poisoned by arsenic seemed neither to be retarded nor hastened, whether they were buried or not; but he admits that parts in contact with an arsenical solution seem preserved from putrefaction. Seemann[1] likewise states, that the bodies of three dogs underwent the usual kind of putrefaction after death. However, that in many cases arsenic modifies the putrefactive process, can hardly, I think, be doubted by those who carefully examine the evidence adduced in favour of this opinion.

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[1] Quoted by Wibmer, in his *Wirkung d. Arzneim. u. Gifte;* and by Dr. Christison, in his *Treatise on Poisons.*

[2] In the dissecting-room of the London Hospital I have often witnessed the powerful and valuable antiseptic properties of arsenious acid. Subjects injected with this substance are but little decomposed at the expiration of one or two months, even during the summer season. But the skin acquires a dark colour, and the body undergoes a remarkable change, which some persons compare to a kind of gelatinization. Arseniuretted hydrogen appears to be evolved. The bones of these subjects are impregnated with arsenic; and black and yellow deposits (the former, perhaps, of metallic arsenic, the latter, of orpiment) are very obvious in the skeletons. The use of arsenical injections are objectionable, on account of the troublesome sores which bodies so preserved give rise to in those engaged in dissection.

[3] Quoted by Wibmer, *op. cit.* i. 305.

Does this mummifying process depend on the chemical influence of the arsenic, or ought we to refer it to a change effected by arsenic on the body, during life, causing "a different disposition and affinity among the ultimate elements of organized matter, and so altering the operation of physical laws in it?" The latter hypothesis appears to me untenable; for, in the first place, there is no evidence of any peculiar change of this kind during life; secondly, that this does not take place appears probable, from the putrefactive process commencing after death as usual; and it would appear that the peculiar influence of the arsenic does not commence, or at least is not evident, until this process has existed for some time, and when a garlic odour is evolved by the body. It is, indeed, true that the quantity of arsenic which has been detected in the body after death, is "almost inappreciably small;" but it is probable that the quantity is much larger than chemists have yet been able to recognise: and it is not at all unlikely that the arsenious acid may enter into new combinations while within the dead body, and in this way become diffused, probably in a gaseous state: the garlic odour which is evolved favours this notion, as well as the statement made by some, that the quantity of arsenic in the body diminishes during the progress of the mummifying process.

Modus Operandi.—When arsenious acid is swallowed, or otherwise applied to a living surface, it becomes absorbed (see *ante*, pp. 101 and 102). The absorption of it is now no longer a matter of doubt; for arsenic has been detected in the blood, in the animal tissues (liver, spleen, kidneys, stomach, and muscles), and in the urine. Although Beissenhirtz[2] was the first who obtained arsenic from the tissues (stomach, cæcum, lungs, liver, heart, and brain,) of animals poisoned by this substance; yet to Orfila is due the credit of having fully established these facts, and applied them usefully in medico-legal investigations. For practical purposes it is useful to know that the poison may be found in the largest quantity in the liver, spleen, and urine. Lassaigne[3] states that he detected it in the infiltrated pleura of a horse.

Arsenious acid appears to exercise a specific influence over several parts of the body, especially the alimentary canal, the heart, and the nervous system. That the *alimentary canal* is specifically affected is shown by the inflammation of the stomach induced by the application of arsenic to wounds, and which, according to Sir B. Brodie, is more violent and more immediate than when this poison is taken into the stomach itself. That the *heart* is also specifically acted on by arsenious acid is proved by the symptoms (the anxiety at the præcordia, the quick irregular pulse, &c.), and by the post-mortem appearances (red spots in the substance of this viscus), and by the diminished susceptibility to the galvanic influence. The specific affection of the *nervous system* is inferred from the symptoms: namely, the headache, giddiness, wandering pains, impaired sensibility of the extremities, delirium, coma, feebleness, lassitude, trembling of the limbs, and the paralysis or tetanic symptoms.

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[1] Quoted by Dr. Christison, *op. cit.* p. 322; also Wibmer, *op. cit.* i. 322.

[2] *De Arsenici efficacia periculis illustrata*, Berol. 1823 (quoted by Wibmer, *Die Wirkung der Arzneimittel. u. Gifte*, Bd. i. S. 316, 1831); and Orfila, *Journ. de Chim. Méd.* t. vi. 2e sér. 1840, and *Traité de Toxicologie*, t. i. p. 347, 1843.—See also the *Report of the French Commissioners*, in the *Journ. de Pharm.* t. xxvii. p. 415.

[3] *Lond. Med. and Phys. Journ.* vol. xlvi. p. 259, Aug. 1821.

The alimentary canal, heart, and nervous system, are not the only parts on which this acid appears to exercise a specific influence: the lungs, the skin, the salivary glands, &c. are also specifically affected. The disorder of the *lungs* is inferred from the local pain, cough, and occasional inflammatory appearances after death. The eruptions and other altered appearances of the *skin*, and the falling off of the hair and nails (sometimes noticed), have led to the idea of the specific influence of arsenious acid on the cutaneous system: an opinion which seems further supported by the fact of the remarkable influence it exercises in some cutaneous diseases, especially lepra. The salivation noticed by Marcus, Ferrier, Mr. Furley, Cazenave, and others, shews that the *salivary glands* are specifically influenced. The swelling of the face, and the irritation and redness of the eyelids, also deserve notice in connection with the specific effects of this poison.

On the whole, it is impossible, I conceive, in the present state of our knowledge, to designate the medicinal effect of arsenic by any term which shall briefly but characteristically declare its physiological properties. The terms *tonic* and *antispasmodic* are quite insufficient for the purpose; nor am I satisfied with the designation *antispasmodic spanæmic* before given to it (see *ante*, p. 185).

USES.—So powerful a poison as arsenic necessarily requires to be employed with great caution, and to have its effects carefully and attentively watched; for it has upon more than one occasion proved fatal when used as a medicinal agent.

In *intermittent fevers and other periodical diseases*, arsenic has been employed with great success. For its introduction into practice in these cases in this country, we are indebted to the late Dr. Fowler, of Stafford;[1] but Lemery and Wepfer appear to have first mentioned its febrifuge property. Dr. Fowler was led to its use from the beneficial effects obtained by the use of the "*Tasteless Ague Drop*," and from the information of Mr. Hughes, that this patent medicine was a preparation of arsenic. The reports published by Dr. Fowler, of the good effects of arsenic in periodical diseases, as observed by himself, by Dr. Arnold, and by Dr. Withering, have been amply confirmed by the subsequent experience of the profession generally. No remedy has been more successful in the treatment of ague. It will not unfrequently put a stop to the disease even when cinchona or the sulphate of quina has failed. Dr. Brown,[2] who has used it in many hundreds of cases, never saw any permanently ill effect arise from it; he considers it superior to crude bark, but inferior to quina: over both it has the advantages of cheapness and tastelessness. It should be given three times a day. It is not necessary to intermit its use during the febrile paroxysm, for I have repeatedly seen it given with the best effects during the attack. In agues accompanied with inflammatory conditions, in which cinchona and sulphate of quina are apt to disagree, arsenic may, according to Dr. Brown, be sometimes administered with the best effects. It is also very successful in relapses after the use of the above remedies. Dr. Macculloch states that one-sixteenth of a grain of white arsenic, given three or four times a day, will sometimes cure ague when the *liquor potassæ arsenitis* fails. A combination of arsenic and cinchona, or arsenic and sulphate of quina, sometimes succeeds, where these agents used separately fail. When the stomach is very irritable, opium is occasionally advantageously conjoined with arsenic. If the bowels be confined during the use of the remedy, gentle laxatives should be employed. Arsenic has been beneficially employed in various other periodical diseases; as periodical headaches, intermittent neuralgias, &c.

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[1] *Medical Report of the Effects of Arsenic*, 1786.

[2] *Cyclopædia of Practical Medicine*, ii. 228.

In various *chronic affections of the skin,* particularly the scaly diseases (lepra, psoriasis, and pityriasis), eczema, and impetigo, arsenic is one of our most valuable agents. I can confidently recommend it in lepra, having seen a large number of cases benefitted by it. Frequently the disease is relieved without any obvious constitutional effect: sometimes a febrile condition of the body is brought on, with a slight feeling of heat in the throat, and thirst; occasionally with an augmentation of appetite. The urine and cutaneous secretion are often promoted; the bowels may be constipated or relaxed; and occasionally, as I have already noticed, salivation takes place. If the patient complain of swelling and stiffness about the face, or itching of the eyelids, the use of the medicine ought to be immediately suspended. Sometimes the disease returns at the end of six or twelve or more months, and again disappears on a return to the use of arsenic. In psoriasis, especially psoriasis guttata, it frequently fails to give relief. Ichthyosis and elephantiasis are said to have been benefitted by the use of it.

According to Mr. Hunt, arsenic exercises an "almost omnipotent influence" over non-syphilitic cutaneous diseases; and he ascribes the numerous failures in the treatment of these maladies to one or more of the following sources:—1st, the syphilitic character of the disease being overlooked; 2dly, the administration of arsenic during the inflammatory or febrile state of the disease; 3dly, the use of it on an empty stomach; 4thly, the exhibition of the remedy in too large doses, and at intervals too distant. He recommends five minims of Fowler's solution three times a day, to begin with, and as soon as the conjunctivitis appears, to reduce the dose; and he deprecates the employment of gradually increasing doses. These are the regulations under which I have usually given it; and though I can bear testimony to the great value of arsenic in skin diseases, my experience does not authorise me to ascribe to it the "almost omnipotent influence" which Mr. Hunt has done, for I have repeatedly witnessed its failure as a therapeutical agent in some of these maladies,[1] especially in superficial lupus, psoriasis guttata, obstinate eczema, &c.

Various chronic affections of the nervous system have been treated by the arsenious acid, and with occasional benefit: for example, neuralgia, epilepsy, chorea,[2] and even tetanus. I have seen arsenic used in a considerable number of epileptic cases, and in none was the disease cured. In some, the fits occurred less frequently, but I am not sure that this was the effect of the medicine. In chorea, I have seen great advantage attend its use;—in fact, I know of no remedy for this disease equal to arsenic, which, in a large proportion of cases, acts almost as a specific. It has also relieved angina pectoris. It is said to possess the power of controlling determinations of blood to the head.[1]

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[1] For further information on the use of arsenic in skin diseases, consult Rayer, *Treatise on Diseases of the Skin,* by Dr. Willis, p. 80; and Mr. Hunt's work, before quoted.

[2] Dr. Gregory, *Med.-Chir. Trans. of London,* xi. 299.

In bites of venomous snakes and of rabid animals, arsenious acid has been recommended. In India, the Tanjore pill (the basis of which is arsenious acid) has long been celebrated for the cure of the bite of the Cobra di Capello, and other venomous serpents. There is, however, no valid reason for supposing that it possesses any remedial power in these cases. Arsenic has been employed as an internal agent in various other diseases—as *chronic rheumatism,* especially when attended with pains in the bones; in *diseases of the bones,* particularly venereal nodes;[2] in *syphilis;* in *passive dropsies;* in the last stage of *typhus,* &c.[3]

Arsenious acid has long been employed as an *external application.* It has been applied and recommended by Sir A. Cooper, Dupuytren, and other high authorities; but its use is always attended with some danger. M. Roux, a celebrated surgeon at Paris, states,[4] that he amputated the breast of a girl, 18 years of age, on account of a scirrhus of considerable magnitude. After the cicatrix had been several days completed, ulceration commenced, accompanied with darting pains. To avoid frightening the girl by the use of the actual cautery, he applied an arsenical paste over a surface of about an inch in diameter. Colic, vomiting, and alteration of countenance, came on the next day; and in two days afterwards she died in violent convulsions. "I am convinced," says M. Roux, "that this girl died poisoned by arsenic." I could quote several other cases illustrative of the same fact, but shall content myself with referring to Wibmer's work[5] for an account of them. The following case, related by Desgranges,[6] shews the danger of applying arsenic externally, even when the skin is sound:—A chamber-maid rubbed her head with an arsenical ointment, to destroy vermin. Though the skin was perfectly sound, the head began to swell in six or seven days after; the ears became twice their natural size, and covered with scabs, as were also several parts of the head; the glands of the jaw and face enlarged; the face was tumefied, and almost erysipelatous. Her pulse was hard, tense, and febrile; the tongue parched, and the skin dry. To these were added excruciating pain, and a sensation of great heat. Vertigo, fainting, cardialgia, occasional vomiting, ardor urinæ, constipation, trembling of the limbs, and delirium, were also present. In a day or two after, the body, and especially the hands and feet, were covered with a considerable eruption of small pimples with white heads. She finally recovered, but during her convalescence the hair fell off.

Though employed as a caustic, yet the nature of its chemical influence on the animal tissues is unknown. Hence it is termed by some a *dynamical* caustic, in opposition to those caustics acting by known chemical agencies. Mr. Blackadder[7] asserts, that the danger of employing arsenic consists in not applying a sufficient quantity. A small quantity, he says, becomes absorbed, whereas a large quantity quickly destroys the organization of the part, and stops absorption.

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[1] *Edinb. Med. and Surg. Journ.* April 1839.

[2] Colhoun and Baer, *Amer. Med. Record,* iii. and iv.

[3] Ferriar, *Med. Hist.* i. 84.

[4] *Nouv. Elem. de Méd.*

[5] *Die Wirkung,* &c.

[6] Orfila's *Toxicol. Générale.*

[7] *Observations on Phagedena Gangrenosa,* Edinb. 1818.

Arsenic has been extolled as a remedy for *cancer*. Justamond[1] esteemed it a specific. Various empirical compounds, which gained temporary notoriety in the treatment of this affection, owe their activity to either arsenious acid or the tersulphuret of arsenicum. But by the best surgeons of the present day it is never employed, because experience has fully shown that it is incapable of curing genuine cancer, while it endangers the lives of the unfortunate patients. It cannot, however, be denied, that diseases resembling cancer have been much relieved, if not cured, by it, and that the progress of cancer itself has occasionally been somewhat checked by its use.

In some forms of severe and unmanageable ulceration, especially *lupus* or *noli me tangere*, arsenical applications are employed with occasional benefit, where all other local remedies fail. In such cases arsenic is not to be regarded as a mere caustic; for other, and far more powerful agents of this kind, are generally useless. It must act by substitution: that is, it sets up a new action in the part, incompatible with that of the disease. The late Baron Dupuytren employed an arsenical dusting powder (composed of 99 parts of calomel and 1 part arsenious acid) in lupus, not as an escharotic, but rather as a specific. Mixed with gum-water, or with fatty matters, it has been sometimes used as a paste or ointment. These applications are to be allowed to fall off spontaneously, and to be repeated five or six times. Sir A. Cooper[2] recommends an arsenical ointment (arsenious acid, sublimed sulphur, aa. ʒj.; spermaceti cerate, ℥j.) to be applied, on lint, for twenty-four hours, and then to be removed. When the slough comes away, the ulcer is to be dressed with simple ointment, and will generally heal in a short time. Cazenave says he has seen arsenical applications used by Biett, and has himself employed them many times, without having met with one instance of injurious consequences. The arsenical paste (arsenious acid, cinnabar and burnt leather, made into a paste with saliva or gum-water) is used where a powerful action is required; but besides the danger of causing constitutional symptoms, to which all arsenical compounds are liable, it is apt to occasion erysipelas.

In *onychia maligna*, my friend Mr. Luke regards an arsenical ointment (composed of arsenious acid, gr. ij., and spermaceti ointment, ℥j.) as almost a specific.

The topical application of arsenic has been successfully employed to relieve *toothache*; but it is a dangerous and at first a painful remedy. A sixteenth of a grain mixed with mastic is placed in the hollow of the decayed tooth. I have been informed that in one case it caused an eruption on the face.

Arsenious acid is a constituent of some of the preparations sold as depilatories.

ADMINISTRATION.—Arsenious acid may be administered, in substance, in doses of from one-sixteenth to one-eighth of a grain, made into pills, with crumb of bread. In making a mass of pills, great care should be taken that the arsenic be equally divided; for this purpose it should be well rubbed in a mortar with some fine powder (as sugar) before adding the bread crumb.

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[1] *An Account of the Methods pursued in the Treatment of Cancerous and Scirrhous Disorders, and other Indurations*, Lond. 1780.

[2] *Lancet*, i. 204.

A much safer mode of exhibition is to give this potent remedy, in the form of solution, with potash (as the *liquor potassæ arsenitis*). But I have already mentioned, that Dr. Macculloch found solid arsenic more efficacious than this solution: and Dr. Physick, of the United States, thinks "that they act differently, and cannot be substituted for one another."[1] The hydrochloric solution (*De Valangin's solution*) is another form for employing it.

Whether given in the solid or liquid form, it is best to exhibit it immediately after a meal, when the stomach is filled with food: for when given on an empty stomach (as in the morning, fasting), it is much more apt to occasion gastric disorder. It is sometimes advisable to conjoin opium, either to enable the stomach to retain it, or to check purging. In debilitated constitutions, tonics may be usefully combined with it. An emetic (as ipecacuanha), or a laxative (as rhubarb), may be employed where the stomach is overloaded, or the bowels confined. Its effects are to be carefully watched, and whenever any unpleasant symptoms (as vomiting, griping, purging, swelling or redness of the eyelids, dryness of throat, ptyalism, headache, or tremors) make their appearance, it will of course be advisable to diminish the dose, or suspend for a few days the use of the remedy. Indeed, when none of these symptoms occur, it is not proper to continue its use more than two weeks without intermitting its employment for a day or two, in order to guard against the occasional ill consequences resulting from the accumulation of the poison in the system.

ANTIDOTES.—In cases of poisoning by arsenic, several indications require to be fulfilled:

1. The first object to be effected is *to expel the poison from the stomach.* For this purpose the stomach-pump should be immediately applied. If this be not in readiness, and vomiting have not commenced, tickle the throat with a feather or the finger, and administer an emetic of sulphate of copper or sulphate of zinc. Promote vomiting by diluent and demulcent liquids; as milk, white of egg and water, flour and water, gruel, sugared water, broths, linseed-tea, oil and lime-water, a mixture of milk, lime-water, and albumen, &c. The liquid serves to promote vomiting; the demulcents (mucilage, albumen, oil, casein, sugar, &c.) invest the poisonous particles, and, therefore, act as mechanical antidotes; while the lime-water is useful by diminishing the solubility of the arsenious acid.

To expel arsenious acid from the intestines, castor oil is the best purgative.

2. The second object is *the employment of mechanical and chemical antidotes.* The uses of mechanical antidotes in cases of poisoning have been before noticed (see *ante*, pp. 154 and 155). The demulcents directed to be used in promoting vomiting are, in fact, mechanical antidotes.

Charcoal, magnesia, hydrated sesquioxide of iron, and any inert powder (as linseed-meal, flour, liquorice-powder, &c.), when swallowed in large quantities, may be occasionally of service, by enveloping the particles of arsenic, and preventing their contact with the gastric surface. Olive oil, on which, according to Dr. Paris,[2] the Cornish miners rely with confidence, can only act mechanically in the way just mentioned.

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[1] *United States Dispensatory.*

[2] *Pharmacologia.*

Of chemical antidotes (see *ante*, pp. 159 and 161), there are none for arsenic on which much reliance can be placed. Those recommended are—animal charcoal (see *ante*, p. 160, foot-note, and p. 316), hydrated sesquioxide of iron, magnesia, and lime-water. But none of these are efficacious as chemical agents unless the poison be in solution. Now, as arsenic is almost invariably taken in a solid form, it follows that the benefit which may be obtained by the use of these agents is generally to be ascribed to their action as mechanical antidotes. With respect to the hydrated sesquioxide of iron, Dr. Maclagan[1] observes that, "as far as chemical evidence goes, at least twelve parts of oxide, prepared by ammonia, and moist, are required for each part of arsenic." It should be stated for "each part of arsenic in solution," as it only acts chemically on the solution. But, as we cannot usually determine how much has been swallowed, Dr. T. R. Beck[2] recommends that we should administer to an adult a table-spoonful, at least,—and to children, a dessert-spoonful, every five or ten minutes, until relief from the urgent symptom is obtained. (For further details, see the article *Ferri Sesquioxydum hydratum*.)

Highly-calcined magnesia has been lately revived by Bussy as a chemical antidote for arsenic. When in the gelatinous or hydrated state, it abstracts arsenious acid from its solution by forming with it a difficultly-soluble arsenite of magnesia.[3]

In conclusion, I may observe that no objection whatever can be raised to the use either of hydrated sesquioxide of iron or of magnesia as antidotes:—neither of them can do harm; both of them certainly are useful as mechanical antidotes: they may be serviceable as chemical antidotes.

3. Another indication is the use of *dynamical antidotes*, or *counter-poisons* (see *ante*, p. 159), agents which are supposed to neutralize or counteract the effects of the poison. Unfortunately we have here no specifics; and the treatment must be conducted on general principles.

When the gastro-enteritis is marked, antiphlogistic measures have been resorted to; such as blood-letting, both general and local, and blisters to the abdomen. But the great depression of the vascular system precludes, in most cases, the use of general blood-letting. Moreover, so long as the poison is in the stomach, this operation is objectionable, on the ground of its promoting absorption. Opium is a very valuable agent. Indeed, Jäger seems to regard it in the light of a counter-poison. However, on this point he has probably taken a too exaggerated view of its efficacy; but it is undeniable that on most occasions it is of great service. If the stomach reject it, we may employ it in the form of clysters. If constipation and tenesmus be troublesome, mild laxatives, especially castor oil, should be exhibited. When there is much depression and collapse, brandy and other stimulants are sometimes requisite.

4. The last indication is the use of *remedies which promote the elimination of the poison from the system after it has been absorbed* (see *ante*, p. 159). To effect this, Orfila recommends the use of diuretics—viz. white wine and water, Selters water, and nitrate of potash; while Flandin, who found them

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[1] *Edinb. Med. and Surg. Journ.* No. 144.

[2] Dr. T. R. Beck, *Lond. Med. Gaz.* Oct. 15, 1841.

[3] For further details regarding the action of hydrated sesquioxide of iron and magnesia as antidotes for arsenical poisoning, the reader is referred to Dr. A. Taylor's work *On Poisons*, pp. 86 and 89.

useless, advises the use of purgatives, and the continuance of the employment of chemical antidotes (calcined magnesia and sulphuretted hydrogen water), to prevent a second absorption (see *ante*, p. 160).

1. **LIQUOR POTASSÆ ARSENITIS**, L.; *Solution of Arsenite of Potash; Liquor Arsenicalis*, E. D.; *Fowler's Solution; Mineral Solution.*—(Arsenious Acid [broken in small pieces, *L.*; in powder, *E.*]; Carbonate of Potash, each grs. lxxx.; Compound Tincture of Lavender, fʒv.; Distilled Water, Oj. Boil the Arsenious Acid and Carbonate of Potash with half a pint of the Water in a glass vessel until they are dissolved. Add the Compound Tincture of Lavender to the cooled liquor. Lastly, add besides, of distilled water, as much as may be sufficient, that it may accurately fill a pint measure, *L. E.*—The preparation of the *Dublin College* is one-ninth weaker: the proportions of materials used are of Arsenious Acid, in powder; Carbonate of Potash, from Tartar, of each sixty grains; Compound Spirit of Lavender, fʒiv.; Distilled Water, Oj. [*wine measure*]).—In this preparation the arsenious acid combines with the potash of the carbonate, and disengages the carbonic acid. $KO,CO^2+AsO^3=KO,AsO^3+CO^2$. A slight excess of carbonate is used. The compound tincture of lavender is used as a colouring and flavouring ingredient. Half an ounce of the solution prepared according to the London or Edinburgh Pharmacopœias contains two grains of arsenious acid. The dose of this solution is four or five minims, gradually and cautiously increased. I have known 15 minims taken three times a day for a week without any ill effects. Dr. Mitchell, of Ohio, has given from 15 to 20 drops three times a day in intermittents.[1] But as some persons are peculiarly susceptible of the influence of arsenic, we ought always to commence with small doses. It has been given to children, and even pregnant women. Dr. Dewees[2] administered it successfully to a child only six weeks old, affected with a severe tertian ague. Dr. Fowler drew up the following table of doses for patients of different ages:—

Ages.	*Doses.*
From 2 to 4 years	from 2 or 3 to 5 drops.
" 5 " 7 "	" 5 " 7 "
" 8 " 12 "	" 7 " 10 "
" 13 " 18 "	" 10 " 12 "
" 18, and upwards	12 "

But it may be remarked that the quantities here indicated are larger than it will be safe, in most cases, to commence with.—Half an ounce taken in the space of five days is supposed to have caused death (see *ante*, p. 659).

2. **LIQUOR ACIDI ARSENIOSI HYDROCHLORICUS**; *Hydrochloric Solution of Arsenious Acid; De Valangin's Solutio Solventis Mineralis.*—Arsenious Acid, gr. xxx.; Hydrochloric Acid, gr. xc.; Distilled Water, f℥xx. Dissolve the arsenious acid in the hydrochloric acid diluted with about f℥j. of water; then add the remainder of the water to the solution.

The late Dr. De Valangin[3] introduced the *solutio solventis mineralis* into medical use. He prepared it by subliming in a bolt-head a mixture of 3 lbs. of arsenious acid and 8 lbs. of common salt. The sublimate was a white powder, which he called the *solvent mineral.* This was dissolved in diluted hydrochloric acid, and formed his *solution of the solvent mineral,* which by some persons has been regarded as a *solution of chloride of arsenic.* He presented the Apothecaries' Company with a quantity of his preparation, as well as with the formula for its manufacture.

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[1] *United States Dispensatory.*

[2] *Philadelphia Journ. of Med. and Phys. Sc.* xiv. 187.

[3] Dr. Franciscus Josephus Pahud de Valangin was a native of Switzerland; but practised in London. He died in 1805. A short sketch of his life, with his portrait, is given in the *European Magazine* for 1805. (See also the *Gentleman's Magazine* for the same year.) He was the author of *A Treatise on Diet, or the Management of Human Life by Physicians*, Lond. 1768.

But by submitting a mixture of arsenious acid and common salt to sublimation, no chemical change is effected. The arsenious acid sublimes unaltered. De Valangin's *solvent mineral* is in reality, therefore, nothing but this acid; and, provided pure arsenious acid be employed, the process of sublimation is unnecessary. Mr. Warington tells me that he has submitted an authentic specimen of De Valangin's solvent mineral to microscopic examination, and finds it to consist of octohedral and tetrahedral crystals of arsenious acid.

By dissolving arsenious acid in hydrochloric acid, we obtain a solution either of the *terhydrochlorate of arsenious acid* or of the *terchloride of arsenic.* $AsO^3 + 3HCl = AsCl^3 + 3HO$. According to Dupasquier,[1] the solution contains terchloride of arsenic; for, when it is submitted to distillation, the distilled product is arseniferous. On repeating the experiment, I find that the quantity of arsenic which distils over is very small; and that the residual liquor in the retort deposits octohedral crystals of arsenious acid.

For the preceding formula for the preparation of De Valangin's solution, I am indebted to Mr. Warington, who tells me that it is the one which is intended to be introduced into the forthcoming new edition of the London Pharmacopœia. De Valangin's solution is considered by some practitioners to be superior to any other preparation of arsenic. Dr. Farre, who has been long practically acquainted with it, kindly informs me that it "effectually cures the worst forms of chorea which resist other remedies. It was recommended to me," he adds, "by the late Dr. Bateman[2] for the cure of lepra vulgaris, which, although that disease may return upon you, it will cure again. It will be introduced into the next Pharmacopœia, it is said, in an improved form,—but I hope it will not be injured; for it is the only safe and effective preparation of arsenic with which I am acquainted."

Although I have on numerous occasions employed De Valangin's solution, I have not hitherto satisfied myself of its superiority to the solution of arsenite of potash, which cures or greatly relieves a very large portion of the cases of chorea and lepra which usually present themselves. It is supposed to be less apt to disturb the stomach on account of its not suffering decomposition and separation of the arsenious acid, as does arsenite of potash, by the acid gastric secretion. Before its absorption, however, its acidity must be neutralized by the bases (soda of the bile principally) which it meets with in the alimentary canal. It is probable, therefore, that the arsenic of De Valangin's solution passes into the blood as arsenite of soda.

One fluidounce of the solution, prepared according to the formula above given, contains only one grain and a half of arsenious acid; whereas the same quantity of Fowler's solution contains four grains of arsenic. It is probable, therefore, that the real explanation of the infrequent occurrence of gastric symptoms under the use of De Valangin's solution is referable to the smaller quantity of arsenic usually administered.—The dose is from ♏iij. to ♏x. thrice daily. Dr. Farre tells me that he always begins with three drops three times a day, and, after a few days, increases one drop per diem (not each dose). In this way he proceeds till the patient takes ten drops thrice daily. Whenever gastric disorder supervenes, the medicine is to be suspended, and to be subsequently renewed in the original dose of three drops.

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[1] *Journ. de Pharmacie,* t. xxvii. p. 717, 1841.

[2] Dr. Bateman (*Practical Synopsis of Cutaneous Diseases*), in noticing the beneficial effects of Fowler's solution in the treatment of lepra, says, in a foot-note, "Another preparation, introduced by the late Dr. De Valangin, is kept at Apothecaries' Hall, under the name of *solutio solventis mineralis,* and is equally efficacious."

Butter of arsenic, or the *terchloride of arsenic* ($AsCl^3$), has been used as a caustic in cancer and venereal warts, but its use requires great caution. Praun[1] employed it in cancer, and Ebers[2] in venereal warts. In one case, where two grains of calomel had been administered internally, salivation followed its use.

3. **PILULÆ ASIATICÆ**; *Asiatic Pills*.[3]—(Arsenious Acid, gr. lv.; Powdered Black Pepper, ʒix.; Gum Arabic, a sufficient quantity to make 800 pills; each of which contains about $\frac{1}{15}$ of a grain of arsenious acid).—These pills are employed in the East for the cure of syphilis and elephantiasis.

4. **UNGUENTUM ARSENICI**; *Arsenical Ointment*.—An ointment containing arsenious acid is used of different strengths by surgeons. For onychia maligna I have already mentioned one containing two grains of arsenic to an ounce of lard or spermaceti ointment. The *Ceratum Arsenici* of the United States Pharmacopœia consists of Arsenious Acid, in very fine powder, ℈j.; Simple Cerate, ℥j. This is used as a dressing for cancerous sores, but must be applied with great circumspection (see another formula at p. 666).

5. **PASTA ARSENICALIS**; *Arsenical Paste*.—Various formulæ for this are given. The *Pulvis Escharotica Arsenicalis* (*Poudre caustique du frère Cosme ou de Rousselot*) of the French Codex is composed of finely levigated Cinnabar, 16 *parts*; powdered Dragon's Blood, 16 *parts*; finely levigated Arsenious Acid, 8 *parts*. Mix intimately. At the time of employing it, it is made into a paste, by means of a little saliva, or mucilage. This preparation is employed to cauterize cancerous wounds. It must be used very cautiously, and applied to limited portions only of the ulcerated surface. I have already referred to its occasional dangerous or fatal effects (see *ante*, p. 665). It deserves especial notice, that this officinal preparation of the French Codex is very considerably stronger than was used either by Rousselot or Cosme, notwithstanding that it is named after them.[4]

99. Arsenici Sulphureta.—Sulphurets of Arsenic.

No less than seven compounds of sulphur and arsenic are noticed by L. Gmelin.[5] Of these, two only require to be noticed here.

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[1] *Anleit. zu d. Krebscur ohne Schnitt*, S. 76 (quoted by Richter, *Ausf. Arzneimittellehre*, Bd. v. S. 768, 1830).

[2] Hufeland's *Journal*, Bd. xxxvii. St. 3, S. 49.

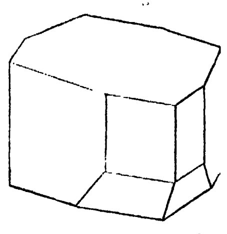
[3] *Asiatic Researches*, vol. ii. p. 153. The formula for these pills, given in the text, is that usually followed (Rayer, *Treatise on Skin Diseases*, by Willis, p. 1215). The original recipe is very indefinite: one tola [105 grs.] of arsenic and six times as much black pepper are to be made into pills "as large as tares or small pulse."

[4] For further information respecting Arsenical Paste, see Patrix, *L'Art d'appliquer la Pâte Arsenicale*, 8vo. Paris, 1816.

[5] *Handbuch d. Chemie*, Bd. ii. 1844.

1. Arsenici Bisulphuretum; *Bisulphuret of Arsenic; Risigallum; Realgar; Red Sulphuret of Arsenic; Red Arsenic; Sandaraca, σανδαράκη; Sandarach.*—It occurs in the mineral kingdom both massive and crystallized. The crystals belong to the oblique prismatic system (see *ante*, p. 142).—Commercial realgar is an artificial product, prepared by submitting to distillation arsenical pyrites. It is met with in the form of red vitreous masses, or as a red powder. It is an energetic poison. It was the agent employed by Mrs. Burdock to destroy Mrs. Smith.[1] The body of the victim was exhumed after having been buried for fourteen months. It was then discovered that the realgar had been transformed into orpiment, which was found in the stomach. Mr. Herapath[2] has shown that ammonia and sulphuretted hydrogen (gases evolved during putrid decomposition) are each capable of converting realgar into orpiment. Heated with the soda-flux, it yields metallic arsenic (see *ante*, pp. 638 and 644). Realgar was used in medicine by the Greeks, Romans, Arabians, Paracelsus, and some few later authorities. At the present time it is not employed for medical purposes, but is used by pyrotechnists, and as a pigment.

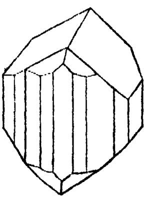
FIG. 126.



Acute Oblique Rhombic Prism of Realgar.

2. Arsenici Tersulphuretum; *Tersulphuret of Arsenic; Auripigmentum; Orpiment; Yellow Sulphuret of Arsenic; Yellow Arsenic; Sesquisulphuret of Arsenic; Sulphoarsenious Acid; King's Yellow.*—This is both found native and prepared artificially. Native orpiment is the *auripigmentum*, or *paint of gold*, of the ancients. It was so called in allusion both to its use and its colour, and also because it was supposed to contain gold. From this term the common name of "*orpiment*," or "*gold paint*," has been derived. Native crystals of orpiment belong to the right prismatic system (see *ante*, p. 141). Artificial orpiment, prepared by submitting to distillation a mixture of arsenious acid and sulphur, is much more poisonous than native orpiment, as it contains, according to Guibourt,[3] 94 per cent. of arsenious acid, and only 6 per cent. of the tersulphuret of arsenic. It is soluble in alkalies (by which it is readily distinguished from sulphuret of cadmium), but is insoluble in hydrochloric acid (by which it is distinguished from the tersulphuret of antimony), and is precipitated from its alkaline solutions by acids. Heated with black flux, it yields metallic arsenicum (see *ante*, pp. 638 and 644). As met with in the shops, it is a powerful poison. It is a constituent of some depilatories (see *ante*, p. 158). According to Dr. Paris, Delcroix's depilatory, called *poudre subtile*, consists of quicklime, orpiment, and some vegetable powder. Orpiment is used by pyrotechnists, and as a pigment.

FIG. 127.



Right Rhombic Prism of Orpiment.

Like realgar, it was employed in medicine by the ancients, but at the present time it is not in use.

100. Arsenici Teriodidum.—Teriodide of Arsenic.

Formula AsI^3. *Equivalent Weight* 453.

Arsenici Iodidum; Iodide of Arsenic; Arsenicum Iodatum; Ioduret or Hydriodate of Arsenic.—This compound is prepared by gently heating, in a tubulated retort placed in a sand-bath, a mixture of one part finely-pulverized metallic arsenic and five parts of iodine: the iodide is afterwards to be sublimed, to separate the excess of arsenicum. The compound thus obtained is an orange-red volatile solid. It is soluble in water, either as teriodide of arsenic or as a compound of hydriodic and arsenious acids. $AsI^3 + 3HO = AsO^3 + HI$. If the solution be rapidly evaporated to dryness, we re-procure the iodide; but if we concentrate, and then place the solution aside, white pearly plates are obtained, which Plisson[4] regarded as iodide of arsenicum, but which, according to Serullas and

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[1] See the account of the celebrated Bristol case of poisoning, in the *Lond. Med. Gaz.* vol. xv. p. 519; and vol. xvi. p. 120.

[2] *Ibid.* vol. xviii. p. 488.

[3] *Hist. abrégée des Drogues simples*, t. i. p. 174, 3me éd. 1836.

[4] *Journ. de Pharmacie*, t. xiv. p. 46, 1828.

Hottot,[1] is a compound of arsenious acid and teriodide of arsenicum (*arsenite of teriodide of arsenicum*).

Iodide of arsenic combines the effects of arsenious acid and iodine. It is a powerful preparation, and, like arsenious acid, requires caution in its use. It becomes absorbed, and is eliminated by the urine, saliva, and perspiration.[2] Dr. Blake[3] injected solutions of it into the veins, but did not find its effects so powerful as might have been expected. Six grains thrown into the veins of a dog had no appreciable effect: fifteen grains immediately arrested the action of the heart.

It has been employed in obstinate skin diseases, as well as in real or simulated cancer. Dr. A. T. Thomson administered it internally with great success in lepra and impetigo. Biett[4] used it externally, in the form of ointment, in tuberculous, herpetic diseases of the skin. In a case of lupus, the ointment has been employed with good effect.

Dr. Thomson employed it in the form of pills, commencing with $\frac{1}{10}$th of a grain and ending with $\frac{1}{3}$rd of a grain.—Biett's ointment consisted of about $2\frac{1}{2}$ grs. of the iodide to ʒj. of lard. About one drachm of this ointment may be used at once.

"An extemporaneous preparation, which is said to combine the virtues of both arsenic and iodine, is said to have been employed successfully in Philadelphia. It is formed as follows:—℞ Liquor. Iodin. comp., ℥j.; Liquor. Potassæ Arsenitis, ʒiv.: M. When mixed together in these proportions, a change is observed in the appearance of the mixture, which is instantaneously rendered almost colourless. The dose is five drops."[5]

Arsenici Superiodidum.—Wackenroder's solution of *superiodide of arsenic* is an aqueous solution of superiodide of arsenic, each drachm of which contains $\frac{1}{48}$th of a grain of metallic arsenic and about $\frac{1}{10}$th of a grain of iodine, or about the $\frac{1}{8}$th of a grain of superiodide of arsenic. Häser gave it in doses of 20 drops twice a day in scirrhus.[6]

Donovan's solution contains teriodide of arsenic and biniodide of mercury. It will be described hereafter (see *Hydrargyri Biniodidum*).

ORDER XXI. ANTIMONY AND ITS COMPOUNDS.

101. Antimonium.—Antimony.

Symbol Sb. *Equivalent Weight* 129.

Stibium.—This substance, though the basis of several important medicinal preparations, is not now used in medicine in the metallic state. In former times, *everlasting* or *perpetual pills* (*pilulæ æternæ* seu *perpetuæ*) and *emetic cups* (*pocula emetica; calices vomitorii*) were made with it. The former were used as purgatives; the latter communicated an emetic quality to wine which had been kept in them for a day or two. To distinguish metallic antimony from the sulphuret, it has been termed *regulus antimonii*, or, when the ingot presents a stellated crystalline texture on its surface, *regulus antimonii stellatus*. When the metal is alloyed with iron, tin, lead, &c., it has been called *regulus antimonii martialis, jovialis, saturninus*, &c.

102. ANTIMONII TEROXYDUM.—TEROXIDE OF ANTIMONY.

Formula SbO^3. *Equivalent Weight* 153.

HISTORY.—Basil Valentine[7] was acquainted with this teroxide, which he called *flowers of antimony* (*flores antimonii*); and he states that it could be procured by various methods.

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[1] *Journ. de Pharmacie*, t. xiv. p. 46, 1828.

[2] *Lond. Med. Gaz.* Jan. 19, 1839; *Lancet* for 1838-9, vol. i.

[3] *Edinb. Med. and Surg. Journal*, April 1839.

[4] Magendie, *Formulaire*, p. 244, 8me édit. 1835.

[5] *New Remedies*, by R. Dunglison, M.D. 4th edit. p. 77, Philadelphia, 1843.

[6] Dierbach, *Die neuesten Entdeckungen in der Materia Medica*, Bd. iii. Abt. ii. S. 1043, 1847.

[7] *Triumphant Chariot of Antimony*, by Kirkringius, p. 91, Lond. 1678.

The compound is known by the various names of *oxide* (*antimonii oxydum*, Ph. Ed.), *protoxide*, and *sesquioxide of antimony*.

NATURAL HISTORY.—It is found native, and is known to mineralogists as *white antimony*. It is found in Bohemia, Saxony, Hungary, &c.

PREPARATION.—There are various methods of preparing this oxide.

1. The *Edinburgh College* directs it to be prepared as follows:—

> "Take of Sulphuret of Antimony, in fine powder, ℥iv.; Muriatic Acid (commercial), Oj.; Water, Ov. Dissolve the sulphuret in the acid, with the aid of a gentle heat; boil for half an hour; filter. Pour the fluid into the water; collect the precipitate on a calico filter; wash it well with cold water, then with a weak solution of carbonate of soda, and again with cold water, till the water ceases to affect reddened litmus paper. Dry the powder over the vapour-bath."

By the action of hydrochloric acid on tersulphuret of antimony, there are obtained the terchloride of antimony, which dissolves in the excess of hydrochloric acid, and hydrosulphuric acid gas, which escapes. $SbS^3+3HCl=SbCl^3+3HS$.

When the solution of terchloride of antimony is diluted with water, a white precipitate of *oxichloride of antimony* ($SbCl^3,5SbO^3$) is produced, which becomes crystalline by standing. $6SbCl^3+15HO=SbCl^3,5SbO^3+15HCl$. This precipitate is called *Algaroth's powder* (*pulvis Algarothi*), after the name of an Italian physician of the 16th century, who recommended its use. It has also been termed the *angelic powder* (*pulvis angelicus*), or *mercury of life* (*mercurius vitæ*).

By long-continued washing with hot water, the oxichloride loses all its chlorine in the form of hydrochloric acid, and pure teroxide of antimony alone remains. $SbCl^3,5SbO^3+3HO=6SbO^3+3HCl$. Washing it with a solution of carbonate of soda also converts it into the teroxide. $SbCl^3,5SbO^3+3(NaO,CO^2)=6SbO^3+3NaCl+3CO^2$.

2. The *Dublin Pharmacopœia* of 1826 directs the *nitromuriatic oxide of antimony* (*antimonii oxydum nitromuriaticum*, Ph. Dub.) to be prepared as follows:—

> Take of prepared Sulphuret of Antimony, *twenty parts*; Muriatic Acid, *one hundred parts*; Nitric Acid, *one part*. Gradually add the sulphuret to the acids, previously mixed in a glass vessel, avoiding the vapours; then, with a heat gradually increased, digest until the mixture ceases to effervesce; then boil during an hour. Receive the cooled and filtered liquor in a gallon of water. Let the oxide of antimony, when it has subsided, be washed with a sufficiently abundant quantity of water, until the decanted fluid shall have become free from acid, which may be ascertained by means of litmus: finally, let the oxide be dried on bibulous paper.

The reaction between the tersulphuret and hydrochloric acid is the same in this as in the preceding process. A small quantity of nitric acid is used to decompose the hydrosulphuric acid remaining in the liquor, and which would impair the colour of the precipitate. The washing deprives the precipitated oxichloride of its chlorine, and the resulting teroxide constitutes the *nitromuriatic oxide of antimony* of the Dublin Pharmacopœia.

3. Another method of obtaining teroxide of antimony is by the action of sulphuric acid on either metallic antimony or the black sulphuret of antimony. By boiling powdered metallic antimony in sulphuric acid, sulphurous acid escapes, and the tersulphate of the oxide of antimony is obtained. $Sb+6SO^3=SbO^3,3SO^3+3SO^2$. By the action of water, this tersulphate of antimony is resolved into an insoluble subsulphate, SbO^3SO^3, and a soluble supersulphate, of antimony. By the action of carbonate of soda, the subsulphate is converted

into the teroxide of antimony. $SbO^3,SO^3+NaO,CO^2=SbO^3+NaO,SO^3+CO^2$. This method of procuring teroxide of antimony was proposed by Mr. R. Phillips[1] in 1811. The late Dr. Babington[2] suggested the substitution of the black sulphuret of antimony for metallic antimony.

For some years past, teroxide of antimony, for the preparation of emetic tartar, has been obtained by some English chemical manufacturers by the action of sulphuric acid on sulphuret of antimony; but it is only recently that this process has been publicly brought forward by M. Hornung[3] as the most economical one for the preparation of oxide of antimony for the manufacture of emetic tartar. As it is probable that it will be generally adopted, I subjoin Hornung's account of it.

Fifteen parts of sulphuret of antimony, in fine powder, were mixed with thirty-six parts of sulphuric acid in an iron vessel, and the mixture exposed to a gentle heat during a night. The mixture had become thick; but, on elevating the temperature and stirring it, it again assumed a liquid condition. After continuing the action for some time, the mass acquired a whitish appearance, a portion of sulphur separated in the fused state, and much sulphurous acid was disengaged. The heat and agitation were continued until in this way the whole of the sulphur was burned out, and sulphurous acid no longer disengaged. When the only vapours evolved were those of sulphuric acid, water was added to wash out the free sulphuric acid; and the residue of subsulphate of antimony was decomposed with carbonate of soda, leaving oxide of antimony in the form of a greenish white powder.

Fifteen parts of sulphuret yielded thirteen parts of dry oxide, which, with the exception of a small quantity of impurity, dissolved in solution of tartaric acid.

In commenting on this process, Mr. Phillips[4] observes that "there is no use in gently heating the mixture for a long time: it may be boiled to dryness at once; and the residue is fit for preparing tartarized antimony when merely washed with water, and without using any carbonate of soda."

By the mutual reaction of sulphuret of antimony and sulphuric acid, we obtain tersulphate of oxide of antimony, sulphurous acid, and sulphur. $SbS^3+6SO^3=SbO^3,3SO^3+3SO^2+3S$. By the heat employed, the sulphur and sulphurous acid are dissipated. By washing, the excess of sulphuric acid is removed, and the tersulphate of the oxide of antimony decomposed into the subsulphate, SbO^3,SO^3, and a supersulphate of antimony. The subsulphate is afterwards converted into the teroxide by the carbonate of soda. $SbO^3,SO^3+NaO,CO^2=SbO^3+NaO,SO^3+CO^2$. By boiling in water, the subsulphate may be deprived of nearly the whole of its sulphuric acid.

Sulphurated Teroxides of Antimony. *Antimony Ash, Glass of Antimony*, and *Saffron of Antimony*, are sometimes prepared and used on account of the teroxide of antimony which they contain: hence they require a short notice.

1. ANTIMONY ASH; *Cinis Antimonii.*—This substance is obtained by roasting powdered black sulphuret of antimony. The process is carried on by some manufacturers of emetic tartar as a cheap method of obtaining oxide of antimony. As I have seen it performed on the large scale in London, the powdered sulphuret was roasted on an iron plate set over a fire: the fumes escaped into a chimney. In this process the sulphur is for the most part burnt off and converted into sulphurous acid, while the antimony abstracts oxygen from the air. The resulting antimony ash is of a grey colour. It is a mixture of *antimonious acid* (SbO^4) with some *teroxide of antimony* (SbO^3) and some unburnt *tersulphuret of antimony* (SbS^3), as well as any foreign matters contained in the original sulphuret which have not been destroyed or expelled by the heat.[5] Part of the antimony is volatilized during the operation.

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[1] *Experimental Examination of the London Pharmacopœia.*

[2] See *Philosophical Magazine* for July 1848.

[3] *Journal de Pharmacie,* Mai 1848; *Pharmaceutical Journal,* October 1848.

[4] *Phil. Mag.* July 1848.

[5] Liebig, *Handwört. d. Chemie,* Bd. i. S. 420.

2. Glass of Antimony; *Vitrum Antimonii.*—To obtain this compound, the black sulphuret of antimony is first roasted, by which antimony ash is obtained (see *supra*). This is then fused in an earthen crucible. The antimonious acid of the antimony ash is deprived of a part of its oxygen by the sulphur of the tersulphuret, and is converted into sulphurous acid, which escapes. It has been analyzed by Soubeiran,[1] who states that it consists of *teroxide of antimony* 91·5, *tersulphuret of antimony* 1·9, *silica* 4·5, and *oxide of iron* 3·2. Mr. R. Phillips[2] says that it consists principally of *teroxide of antimony*, some *tersulphuret*, and about five per cent. of *silica*. It has been used to furnish teroxide of antimony in the preparation of emetic tartar.

3. Saffron of Antimony; *Crocus Antimonii; Crocus Metallorum.*—Obtained by deflagrating a mixture of equal parts of black sulphuret of antimony and nitrate of potash; the resulting fused mass (sometimes called *liver of antimony, hepar antimonii*) is to be separated from the scoriæ, reduced to a fine powder, boiled in water, and repeatedly washed: it then constitutes *washed saffron of antimony* (*crocus antimonii lotus*), which was formerly used in the preparation of emetic tartar.—The fused mass is a mixture of sulphate of potash, teroxide of antimony combined with potash, oxisulphuret of antimony, and tersulphuret of antimony combined with sulphuret of potassium. The water abstracts the sulphate of potash, the caustic potash, and the sulphuret of potassium.

Liver of antimony is also obtained by fusing together black sulphuret of antimony and carbonate of either potash or soda: the product consists of a saline compound of tersulphuret of antimony and alkaline sulphuret, mixed with a compound of teroxide of antimony and potash.

Ruby of antimony (*rubinus antimonii; regulus antimonii medicinalis*) is obtained by fusing together five parts of black sulphuret of antimony and one part of carbonate of potash, and separating the upper layer (sulphoantimonite of potassium) from the lower one, which consists of a fused mass composed of tersulphuret of antimony with a little of the teroxide.

Properties.—Teroxide of antimony occurs native in tabular and acicular crystals, which belong to the right prismatic system. When prepared in the moist way it is a white powder, which becomes yellow by heat, and fuses at a full red heat into a yellow fluid, which concretes, by cooling, into a crystalline mass. If subjected to heat in the open air, it absorbs oxygen, and becomes antimonious acid (SbO^4).

Characteristics.—Heated in liquid hydrochloric acid, it completely dissolves: the solution contains terchloride of antimony, which, when mixed with water, yields a white precipitate (*oxichloride of antimony*, $SbCl^3,5SbO^3$). Hydrosulphurets form a red precipitate (SbS^3) in the solution of the terchloride. Boiled with a solution of bitartrate of potash, it is dissolved: the solution yields, on cooling, crystals of emetic tartar ($KO,SbO^3,\bar{T},2HO$), the characteristics of which will be hereafter given. Teroxide of antimony melts before the blowpipe, and is volatilized in the form of a white vapour.

Composition.—Teroxide of antimony has the following composition:—

	Atoms.	*Eq. Wt.*	*Per Cent.*	*Berzelius.*	*John Davy.*
Antimony	1	129	84·31	84·319	85
Oxygen	3	24	15·69	15·681	15
Teroxide of Antimony	1	153	100·00	100·000	100

Purity.—The Edinburgh College gives the following characteristics of its purity:—

"Entirely soluble in muriatic acid, and also in a boiling mixture of water and bitartrate of potash; snow-white; fusible at a full-red heat."

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[1] *Journal de Pharmacie*, t. x. p. 528.

[2] *Translation of the Pharmacopœia of the Royal College of Physicians* for 1824, p. 81.

PHYSIOLOGICAL EFFECTS AND USES.—Teroxide of antimony possesses similar medicinal properties to emetic tartar, in the preparation of which it is used. It is rarely employed as a medicine. The oxichloride of antimony is uncertain in its operation.

ADMINISTRATION.—The oxichloride of antimony is sometimes given in doses of from one to ten grains.

103. PULVIS ANTIMONII COMPOSITUS.—COMPOUND POWDER OF ANTIMONY.

HISTORY.—Dr. James, who died in 1776, prepared a celebrated patent medicine, long known as the *fever powder of Dr. James* (*pulvis febrifugus Jacobi*), or *Dr. James's powder* (*pulvis Jacobi*). The discovery of it was subsequently claimed for a German of the name of Schwanberg.[1] The specification which Dr. James lodged in the Court of Chancery is so ambiguously worded, that we cannot prepare his powder by it. Hence the present preparation has been introduced into the Pharmacopœia as a succedaneum for it. In preceding editions of the London Pharmacopœia, as well as in the present Edinburgh and Dublin Pharmacopœias, the name given to it is *pulvis antimonialis* (*antimonial powder*); but in the edition for 1836 this name was unnecessarily (as I conceive) altered to *pulvis antimonii compositus*.

PREPARATION.—All the British Colleges give directions for its preparation.

The *London College* orders, of Sesquisulphuret of Antimony, powdered, lbj.; Horn Shavings, lbij. Mix, and throw them into a crucible red-hot in the fire, and stir constantly until vapour no longer arises. Rub that which remains to powder, and put it into a proper crucible. Then apply fire, and increase it gradually, that it may be red-hot for two hours. Rub the residue to a very fine powder.

The *Edinburgh College* directs equal weights of Sulphuret of Antimony, in coarse powder, and Hartshorn in shavings, to be used. "Mix them, put them into a red-hot iron pot, and stir constantly till they acquire an ash-grey colour, and vapours no longer arise. Pulverise the product, and put it into a crucible with a perforated cover, and expose this to a gradually-increasing heat till a white heat be produced, which is to be maintained for two hours. Reduce the product, when cold, to fine powder.

The process of the *Dublin College* is essentially similar to that of the London College.

Manufacturers usually substitute bone sawings for hartshorn shavings.

The following is the *theory* of the process: the gelatinous matter of the horn (or bones) is decomposed and burned off, leaving behind the earthy matter (triphosphate of lime $3CaO,cPO^5$, with a little calcareous carbonate CaO,CO^2). The sulphur (S^3) of the tersulphuret (SbS^3) is expelled in the form of sulphurous acid ($3SO^2$), while the antimony attracts oxygen from the air, forming antimonious acid (SbO^4), and a variable quantity of teroxide of antimony (SbO^3). By the subsequent heating the teroxide is, for the most part, converted into antimonious acid; but one portion is usually left unchanged, while another is volatilized. The carbonate of lime of the horn is decomposed by the united agencies of heat and antimonious acid: carbonic acid is expelled, and a small quantity of antimonite of lime formed. The sides of the crucible in which the second stage of the process has been conducted, are found, at the end of the operation, to be lined with a yellow glaze, and frequently with yellow crystals of teroxide.

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[1] *Affidavits and Proceedings of W. Baker*, Lond. 1754.

PROPERTIES.—Antimonial powder is white, gritty, tasteless, and odourless. Boiling water extracts the antimonite (and, according to Dr. Maclagan, superphosphate) of lime: the liquid becomes cloudy on cooling. Hydrochloric acid, digested in the residue, dissolves the triphosphate of lime, all the teroxide of antimony, and that portion of the antimonious acid which was in combination with lime. When examined by the microscope, antimonial powder appears to be an amorphous granular powder.

Characteristics.—The solution obtained by boiling antimonial powder in distilled water occasions white precipitates, soluble in nitric acid, with oxalate of ammonia, nitrate of silver, and acetate of lead. The precipitate with the first of these tests is oxalate of lime (CaO,C^2O^3), with the second phosphate of silver ($2AgO,bPO^5$), and with the third phosphate of lead ($2PbO,bPO^5$). Hydrosulphuric acid gas transmitted through the solution, produces an orange-red precipitate. If the portions of antimonial powder not dissolved by distilled water be digested in boiling liquid hydrochloric acid, a solution is obtained, which, on the addition of distilled water, becomes turbid, and deposits a white powder (*oxichloride of antimony*, $SbCl^3,5SbO^3$): at least I have found this to take place with several samples of antimonial powder which I have examined, and the same is noticed by Dr. Barker;[1] but neither Mr. Phillips[2] nor Dr. Maclagan[3] have observed it. Hydrosulphuric acid gas, transmitted through the hydrochloric solution, causes an orange-red precipitate: if this be separated by filtering, and the solution boiled to expel any traces of hydrosulphuric acid, a white precipitate (*triphosphate of lime*, $3CaO,cPO^5$) is thrown down on the addition of caustic ammonia. That portion of antimonial powder which is not dissolved by hydrochloric acid is antimonious acid: if it be mixed with soda, and heated on charcoal in the interior flame of the blowpipe, it is converted into globules of metallic antimony.

> "Distilled water, boiled with it and filtered, gives, with sulphuretted hydrogen, an orange precipitate: muriatic, digested with the residue, becomes yellow, does not [*sometimes does, according to my experiments*] become turbid by dilution, but gives a copious orange precipitate with sulphuretted hydrogen."—*Ph. Ed.* 2d edit. 1841.

COMPOSITION.—*Dr. James's powder* has been analysed by Dr. Pearson,[4] by Mr. Phillips,[5] by Berzelius,[6] by M. Pully,[7] by Dr. D. Maclagan,[8] and was imperfectly examined by Mr. Chenevix.[9] *Antimonial powder* has been analyzed by Mr. Phillips,[10] and by Dr. D. Maclagan.[11] Their results are, for the most part, shown in the following table:—

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[1] *Observations on the Dublin Pharmacopœia*, 204.

[2] *Ann. Phil.* iv. N.S. 266.

[3] *Edinburgh Med. and Surg. Journal*, No. 135.

[4] *Phil. Trans.* lxxxi. for 1791, p. 317.

[5] *Ann. Phil.* N.S. vi. 187.

[6] *Traité de Chimie*, iv. 481.

[7] *Ann. de Chim.* 1805, lv. 74.

[8] *Op. supra cit.*

[9] *Phil. Trans.* for 1801, p. 57.

[10] *Ann. Phil.* N.S. iv. 266.

[11] *Op. cit.*

	JAMES'S POWDER.					ANTIMONIAL POWDER.		
	Pearson	Phillips.	Berzel.	Maclagan.		Phillips.		Maclagan.
		Newbury's		Newbury's	Butler's	1st samp.	2d samp.	
Antimonite of Lime [with some superphosphate, *Maclagan*]	—	—	1	3·40	2·25	—	—	0·8
Teroxide of Antimony ...	—	—	—	2·89	9·80	—	—	3·98
Antimonious Acid.........	57	56·0	66	43·47	34·21	35	38	50·09
Triphosphate of Lime	43	42·2	33	50·24	53·21	65	62	45·13
Loss [Teroxide of Antimony and impurity, *Phillips*]	—	1·8	—	—	0·53	—	—	—
	100	100·0	100	100·00	100·0	100	100	100·00

According to the Edinburgh Pharmacopœia (2d ed. 1841), antimonial powder is "a mixture chiefly of *antimonious acid* and *phosphate of lime* with some *sesquioxide* [teroxide] *of antimony* and a little *antimonite of lime.*"

Pully found *sulphate of potash* and *hypo-antimonite of potash* in James's powder. Mr. Brande has found as much as 5 per cent. of teroxide of antimony in the antimonial powder of the shops.

The *antimonite of lime* is obtained in solution by boiling antimonial powder in distilled water: the greater part of it deposits as the solution cools. The existence of *superphosphate* was inferred by Dr. Maclagan from the precipitates produced with the salts of lead and nitrate of silver. Mr. Phillips states that it contains but little, if any, *teroxide of antimony,* because the hydrochloric solution did not let fall any precipitate on the addition of water. But a small quantity of teroxide may be dissolved in excess of this acid without our being able to obtain any evidence of it by the action of water. Dr. Maclagan[1] has shown, that if hydrosulphuric acid gas be transmitted through the solution, an orange-red precipitate is obtained, which he supposes to be an indication of the presence of teroxide. But unless the antimonial powder be boiled *repeatedly* in water, to remove completely the antimonite of lime, this test cannot be relied on; for if the least trace of this salt be present, on the addition of hydrochloric acid a solution is obtained, which not only produces an orange-red precipitate with hydrosulphuric acid, but even causes a white precipitate on the addition of water.

PHYSIOLOGICAL EFFECTS.—Antimonial powder is most unequal in its operation,—at one time possessing considerable activity, at another being inert, or nearly so. This depends on the presence or absence of teroxide of antimony, which may be regarded as constituting its active principle, and which, when present, is found in uncertain and inconstant quantity. Moreover, this variation in the composition of antimonial powder cannot be regarded as the fault of the manufacturer, since it depends, as Mr. Brande[2] has justly observed, "upon slight modifications in the process, which can scarcely be controlled."

Mr. Hawkins gave ʒj. morning and evening without any obvious effect; and the late Dr. Duncan, jun. administered ℈j. and ʒss. doses, several times a day, without inducing vomiting or purging.[3] Dr. Elliotson[4] found even

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[1] *Op. cit.*

[2] *Manual of Pharmacy,* 3d edit. p. 292.

[3] *Edinburgh New Dispensatory,* 11th edit.

[4] *Cases illustrative of the Efficacy of the Hydrocyanic Acid,* p. 77.

120 grains nearly inert; nausea alone being in some of the cases produced. In these instances I presume it contained little or no teroxide.

But, on the other hand, a considerable number of practitioners have found it to possess activity. Dr. Paris[1] observes, that "it will be difficult for the chemist to persuade the physician that he can never have derived any benefit from the exhibition of antimonial powder." I have above stated that the experiments on which Mr. Phillips founds his assertion that this preparation contains but little if any teroxide, are inconclusive, as Dr. Maclagan has shewn. I am acquainted with one case in which it acted with great activity. A workman employed in the manufacture of this powder in the laboratory of an operative chemist in London, took a dose of it (which, from his account, I estimate at half a teaspoonful), and, to use his own words, "it nearly killed him." It occasioned violent vomiting, purging, and sweating.

Dr. James's powder, which some practitioners consider as more active and certain than our antimonial powder, appears to be equally inconstant in its operation. Dr. D. Munro,[2] who frequently used this powder, and saw Dr. James himself, as well as other practitioners, administer it, observes—"like other active preparations of antimony, it sometimes acts with great violence, even when given in small doses; at other times a large dose produces very little visible effects. I have seen three grains operate briskly both upwards and downwards; and I was once called to a patient, to whom Dr. James had himself given five grains of it, and it purged and vomited the lady for twenty-four hours, and in that time gave her between twenty and thirty stools; at other times I have seen a scruple produce little or no visible effect." Dr. Cheyne[3] thought highly of it in the apoplectic diathesis: but he used it in conjunction with bleeding, purgatives, and a strict antiphlogistic regimen.

The preceding facts seem to me to shew the propriety of omitting the use of both antimonial and James's powder, and substituting for them some antimonial of known and uniform activity; as emetic tartar.

USES.—Antimonial powder is employed as a sudorific in fevers and rheumatic affections. In the former it is given either alone or in combination with mercurials: in the latter it is frequently conjoined with opium as well as with calomel. In chronic skin diseases it is sometimes exhibited with alteratives.

ADMINISTRATION.—The usual dose of it is from 3 or 4 to 8 or 10 grains, in the form of powder or bolus.

104. ANTIMONII TERSULPHURETUM.—TERSULPHURET OF ANTIMONY.

Formula SbS^3. *Equivalent Weight* 177.

Two forms of this compound are used in medicine—the one crystalline, the other amorphous.

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[1] *Pharmacologia.*

[2] *Treatise on Med. and Pharm. Chem.* i. 367.

[3] *Dubl. Hosp. Rep.* i. 315.

1. Antimonii Tersulphuretum Crystallisatum.—Crystallized Tersulphuret of Antimony.

HISTORY.—Black sulphuret of antimony was known in the most ancient times, being used by the Asiatic and Greek ladies as a pigment for the eye-brows.[1] It was formerly called *stimmi* (στίμμι vel στίμμις), *stibium* (στίβι), *platyophthalmon* (πλατυόφϑαλμον), or *larbason*[2] (λάρβασον). It has also been called κόχλος. In the native state it is technically termed *antimony ore*, and when first fused out of its gangue, *crude antimony*, or *sulphuret of antimony*. It is the *antimonii sulphuretum* of the Edinburgh and Dublin Pharmacopœias; the *antimonii sesquisulphuretum* (*sesquisulphuret of antimony*) of the London Pharmacopœia.

NATURAL HISTORY.—Tersulphuret of antimony is found native in various parts of the world, especially in Hungary, in the Hartz, in France, in Cornwall, and in Borneo. From the latter place it is imported into this country by way of Singapore, being brought over as ballast to the vessels. In the years 1835-36 and 37, the quantities of ore imported were respectively 645, 825, and 629 tons (*Trade List*, Jan. 10, 1837, and Jan. 9, 1838). In 1840, there were imported 627 tons.

PREPARATION.—The old method of separating the tersulphuret from its siliceous gangue was to melt it in a covered crucible or pot, in the bottom of which there were several holes, through which the fused sulphuret passed into an inferior or receiving pot. According to Gensenne's method, the melting-pots were placed in a circular reverberatory furnace, and were connected by curved earthen tubes with the receiving pots which were on the outside of the furnace. At La Vendée, neither vessels nor tubes are used: the ore is placed on the bed of a reverberatory furnace, in which is an aperture to allow of the passage of the fused tersulphuret, which flows into a receiving vessel placed externally to the furnace.[3]

PROPERTIES.—The fused tersulphuret (called *common* or *crude antimony*) occurs in commerce in roundish masses, called loaves or cakes: these, when broken, present a striated crystalline appearance, a dark steel or lead grey colour, and a metallic brilliancy. The commercial tersulphuret is opaque, tasteless, odourless, brittle, easily pulverizable, and has a sp. gr. of about 4·6. Its powder is black, but that of pure tersulphuret is reddish-black. It is a little less fusible than metallic antimony. It is volatile, but cannot be distilled; and it appears to be partially decomposed by heat, for, when heated in an earthen crucible for an hour, it loses from 10 to 20 per cent. of its weight.[4] By roasting, it is converted into *antimony-ash* (see *ante*, p. 675). When reduced to a very fine powder by levigation and elutriation, it constitutes the *antimonii sulphuretum præparatum* of the Dublin Pharmacopœia.

Characteristics.—It fuses and is dissipated before the blowpipe, with a smell of sulphurous acid and the formation of a white smoke (SbO^3). Digested in hydrochloric acid, it evolves hydrosulphuric acid, and forms a solution of terchloride of antimony ($SbCl^3$), which produces a white precipitate (*oxichloride of antimony*, $SbCl^3,5SbO^3$) with water, and an orange-red one (SbS^3) with hydrosulphuric acid. If a current of hydrogen gas be passed over heated tersulphuret of antimony, metallic antimony and hydrosulphuric acid gas are obtained: the metal decomposes nitric acid, and yields a white powder: it readily dissolves in nitro-hydrochloric acid ($SbCl^3$).

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[1] 2 *Kings*, ix. 30; *Ezekiel*, xxiii. 40; Pliny, *Nat. Hist.* xxxiii.

[2] Dioscorides, lib. v. cap. 99.

[3] Dumas, *Traité de Chimie*, iv. 160.

[4] Berthier, *Traité des Essais*, ii. 490.

COMPOSITION.—Tersulphuret of antimony has the following composition:—

	Atoms.	*Eq. Wt.*	*Per Cent.*	*Berzelius.*	*Thomson.*
Antimony	1	129	72·88	72·8	73·77
Sulphur	3	48	27·12	27·2	26·23
Tersulphuret of Antimony	1	177	100·00	100·0	100·00

IMPURITIES.—The crude antimony of commerce is rarely, if ever, quite pure. It frequently contains the sulphurets of iron, lead, arsenicum, and copper, and on this account is not adapted for medicinal use. When pure, it is completely soluble in hydrochloric acid; but, when mixed with sulphuret of arsenicum, this remains undissolved, and may be detected by reducing it with a mixture of charcoal and carbonate of soda (see *ante*, p. 644). If the hydrochloric solution be diluted with water (so as to precipitate the greater part of the antimony), the presence of lead, iron, or copper, in the filtered liquor, may be detected by the appropriate tests for these metals, hereafter to be mentioned.

With heat, it is totally dissolved by hydrochloric acid. From the acid in which it is boiled, a white precipitate is thrown down by distilled water; from the strained liquor, hydrosulphuric acid afterwards throws down a reddish coloured substance.—*Ph. Lond.*

"Entirely soluble in muriatic acid, with the aid of heat."—*Ph. Ed.*

PHYSIOLOGICAL EFFECTS. *α. On Animals.*—Rayer[1] introduced half an ounce of it into the cellular tissue of the back of a dog, but no effects resulted from it. Fifteen grains placed in the peritoneal sac caused inflammation, and in twenty-four hours death, but without any peculiar symptoms. Moiroud[2] says that, given to horses in doses of from two to four ounces, it acts as an excitant, causing increased frequency of pulse and respiration and softer stools.

β. On Man.—In most cases it produces no obvious effects, even when taken in very large doses. Rayer[3] gave half an ounce of it in powder for several days without the slightest effect. Cullen,[4] however, has seen it cause nausea and vomiting in one or two instances in which it was largely employed. Rayer says that the decoction of it is much more active than an equal quantity of the same preparation in powder. How are these facts to be explained? He ascribes the activity of the decoction to arsenious acid, formed by boiling sulphuret of arsenicum (contained in the ordinary crude antimony) with water; for Guibourt[5] obtained in this way $1\frac{44}{100}$ grs. of arsenious acid by boiling an ounce of crude antimony. But the presence of arsenic is not necessary to explain the greater activity of the decoction, since, by long-continued boiling with water, the tersulphuret of antimony yields hydrosulphuric acid and teroxide of antimony.[1] The occasional nausea and vomiting may arise from the decomposition of the sulphuret by the fluids in the alimentary canal.

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[1] *Dict. de Méd. et Chir. Pratiq.* iii. 54.

[2] *Pharm. Vétér.* 428.

[3] *Op. cit.*

[4] *Treat. of Mat. Med.* ii. 482.

[5] Rayer, *op. supra cit.*

USES.—As a medicinal agent, it is occasionally employed as a diaphoretic and alterative in some skin diseases, especially lepra and scabies, in scrofula and glandular affections, and in rheumatism and gout.

As a pharmaceutical and chemical agent, it is a most important substance, being the source from which the metal, and all its compounds, are procured.

ADMINISTRATION.—The usual dose of it, when taken internally, is from ten to thirty grains of the powder; but several drachms of it have been taken without much effect. The *Tisan de Feltz*, which is occasionally used in skin diseases, is prepared by boiling Sarsaparilla, ℥j. and Crude Antimony (tied up in a bag), ʒj. in a pint and a half of Water; then add Isinglass, ʒiv., previously dissolved in water, and reduce the whole (by boiling) to a pint, which is to be taken during the day.[2]

ANTIMONII SULPHURETUM PRÆPARATUM, D.; *Prepared Sulphuret of Antimony*. (Take of Sulphuret of Antimony any requisite quantity. Reduce to powder, according to the mode directed in the preparation of chalk, and let the most subtile particles be preserved for use.)—The powder sold in the shops as prepared sulphuret is usually obtained by grinding in mills without elutriation. Its uses are those of the sulphuret before described.

2. Antimonii Tersulphuretum Amorphum.—Amorphous Tersulphuret of Antimony.

HISTORY.—Red tersulphuret of antimony was known to Basil Valentine,[3] who calls it *sulphur of antimony*. His directions for preparing it are as follows:—Grind antimony to a fine powder, which is to be boiled for two hours, or a little longer, in a sharp lye of beech-wood ashes. Filter the boiled liquor, and pour over it vinegar: the red sulphur of antimony will then be precipitated.

The discovery of *mineral kermes* (so called on account of its similarity in colour to the insect kermes, *Coccus Ilicis*) is usually ascribed to the celebrated Glauber, one of whose pupils communicated the mode of preparing it to M. de Chastenay, by whom it was communicated to M. de la Ligerie. The latter gave a portion of the medicine to Simon, a Carthusian friar, who effected a remarkable cure with it: hence it obtained the name of *Carthusian powder*, *poudre des Chartreux*, or *pulvis Carthusianorum*. The secret of its preparation was purchased of M. de la Ligerie by the king of France.[4]

NATURAL HISTORY.—Amorphous tersulphuret of antimony does not occur native. The mineral called *red antimony* is composed of $SbO^3,2SbS^3$.

VARIETIES.—Two varieties of amorphous tersulphuret of antimony are employed in medicine; one is commonly known as mineral kermes, the other is the precipitated sulphuret of antimony.

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[1] Geiger, *Hand. d. Pharm.*

[2] Rayer, *Treatise on Diseases of the Skin*, by Dr. Willis, p. 1223.

[3] *Basil Valentine, his Triumphant Chariot of Antimony, with Annotations of* Theodore Kirkringius, M.D. p. 131, Lond. 1678.

[4] Lemery, *Sur une Préparation d'Antimoine, appellée communément Poudre des Chartreux, ou Kermes Mineral*, in the *Mémoires de l'Academie Royal*, Année, 1720, p. 417. Paris. 1722.

a. *Kermes Minerale.—Mineral Kermes.*

PREPARATION.—This is prepared both by the humid and by the dry way; and the French Codex gives directions for its preparation by both methods.

α. By the humid way.—This is directed to be prepared as follows:—

Take of Crystallized Carbonate of Soda, 128 parts; Water, 1280 parts; Sulphuret of Antimony, 6 parts. Dissolve the carbonate of soda in the water, by the aid of heat, in a cast-iron pan. Add the sulphuret of antimony, reduced to a fine powder, and boil the mixture for an hour, constantly stirring it with a wooden spatula: filter the boiling solution into an earthern pan previously heated, and containing a small quantity of very hot water. Let the solution cool as slowly as possible; collect the red powder which is deposited on a close cloth, and wash on the filter with cold water. Press the washed powder, and dry it in a stove moderately heated.

The *theory* of this process is as follows:—When tersulphuret of antimony is boiled with a solution of carbonate of soda, a portion of the latter is resolved into carbonic acid and soda. The soda reacts on the tersulphuret of antimony, and produces sulphuret of sodium and teroxide of antimony. $3NaO + SbS^3 = 3NaS + SbO^3$. The sulphuret of sodium dissolves some tersulphuret of antimony, the quantity of which is greater in proportion as the liquid is hotter and more concentrated. $3NaS + xSbS^3$. The teroxide of antimony combines with soda, $NaO + SbO^3$.

As the solution cools, amorphous red tersulphuret of antimony is deposited. This is *kermes minerale*. If the quantity of soda employed be insufficient to hold the whole of the teroxide in solution, a portion of this is also deposited, as the liquid cools, in the form of acuminated six-sided prisms or needles, which by the microscope are seen to be mechanically mixed with the red tersulphuret (H. Rose).

The relative proportions of sulphuret of antimony and alkaline carbonate directed to be employed by different authorities are remarkably different. Whatever process be followed, it is essentially requisite, in order to obtain good coloured kermes of a fine and velvety quality, that the solution be cooled as slowly as possible. This, in fact, is the principal secret in its manufacture.

Both Berzelius[1] and Rose[2] state that mineral kermes contains some alkaline sulphuret. According to Rose, it is in combination with pentasulphuret of antimony, the formation of which depends on the absorption of atmospheric oxygen by the solution. $2O + 3(NaS,SbS^3) = 2NaO + NaS,SbS^5 + 2SbS^3$.

β. By the dry way.—The process of the French Codex for *kermes igne paratum* is as follows:—

Take of Sulphuret of Antimony, 500 parts; Carbonate of Potash, 1000 parts; and Sulphur, sublimed and washed, 30 parts. Carefully mix these three substances, and fuse in a Hessian crucible. Pour the mass, while liquid, into an iron mortar, and, when cold, reduce it to powder. Then boil the powder in an iron pan, with 10000 parts of water, filter the boiling liquor, allow it to cool slowly, then decant it, and collect the kermes on a filter; wash it and dry it as already mentioned.

The quantity of kermes obtained by this process is greater, but less fine, than that procured by the preceding process; and it ought to be exclusively reserved for veterinary medicine.

This is Baumé's method of preparing kermes. According to Berzelius, the best proportions of the ingredients are 1 part of pure carbonate of potash, and $2\frac{2}{3}$ parts of tersulphuret of antimony. The changes effected by the fusion are analogous to those before explained. $4(KO,CO^2)+4SbS^3=KO,SbO^3+3(KS,SbS^3)+4CO^2$. The *Codex* obviously directs an excess of carbonate of potash to be used. The addition of sulphur augments the quantity, but injures the colour, of the kermes, probably because it promotes the formation of pentasulphuret of antimony, SbS^5.

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[1] Schweigger's *Journal*, Bd. xxxiv. S. 58; also, Poggendorff's *Annalen*, Bd. xx. u. xxxvii.

[2] Poggendorff's *Annalen*, Bd. xlvii. S. 323 (also, *Berl. Jahrb. für die Pharmacie*, Bd. xlii. 1839).

PROPERTIES.—Mineral kermes is an odourless, tasteless, brownish-red powder, insoluble both in water and in alcohol. Examined by the microscope, it is seen to consist of a reddish or brownish granular mass, which, when the kermes contains teroxide of antimony, is intermixed with acuminated prisms or small acicular crystals of this substance. Dilute mineral or vegetable acids abstract any contained teroxide: concentrated hydrochloric acid decomposes the tersulphuret. $SbS^3+3HCl=SbCl^3+3HS$. Mineral kermes is completely soluble in hydrosulphuret of ammonia.

COMPOSITION.—The following is the composition of mineral kermes according to H. Rose:—

Kermes prepared by boiling with Carbonate of Soda; but not very carefully dried.		*Kermes prepared by boiling with Potash or its Carbonate.*			
			With Carbonate of Potash.	With Caustic Potash, and slightly washed.	The same, washed for a long time.
Antimony	67·81	Antimony	69·00	61·91	67·08
Sulphur............	28·24	Sulphur............	28·41	30·26	29·44
Sodium	1·33	Potassium	2·25	5·66	3·48
Water	2·62	Water	—	2·17	—
	100·00		99·66	100·00	100·00

According to Rose, kermes consists of amorphous tersulphuret of antimony, with the sulphantimoniate of either sodium or potassium. The formula for that prepared by boiling crude antimony with caustic potash, and washed for a short time only, consists of $2SbS^3+KS,SbS^5+2Aq$. If the same kermes be washed for a long time, its formula is $9SbS^3+KS,SbS^5$.

Berzelius and Fuchs, as well as Rose, are of opinion that pure mineral kermes is an amorphous tersulphuret of antimony.

But most chemists who have analysed this substance have detected in it teroxide of antimony. Rose considers this an accidental admixture arising from the use of an insufficient quantity of alkali to retain the teroxide in solution. Liebig,[1] on the other hand, regards it as an essential constituent, and gives as the formula for kermes $2SbS^3+SbO^3$; and its composition, according to this view, may be thus stated:—

	Atoms.	*Eq. Wt.*	*Per Cent.*
Tersulphuret of Antimony..................	2	354	69·8
Teroxide of Antimony	1	153	30·2
	1	507	100·0

PHYSIOLOGICAL EFFECTS.—The effects of mineral kermes, of the golden sulphuret of antimony, and of the oxysulphuret of antimony of the London

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[1] *Handwört. d. Chemie,* Bd. i. S. 427; *Journ. de Pharm.* t. 25, p. 654, 1839.

Pharmacopœia, are all similar in their character, though varying somewhat in degree. They are more active in proportion as the quantity of teroxide which they may contain is greater. It is probable, however, that kermes mineral, which is entirely devoid of teroxide, is not without some medicinal activity, as it may become soluble in the gastro-intestinal juices, and thereby acquire activity. Kermes mineral is usually stronger than the golden sulphuret of antimony.

The effects of kermes mineral are similar to those of other antimonial compounds (see *ante*, p. 184), and which will be more fully noticed hereafter (see *Antimonii et Potassæ Tartras*). In small doses it is sudorific and liquefacient (see *ante*, p. 175); in large doses, emetic and purgative.

USES.—In England mineral kermes is scarcely employed; but in some parts of Europe, especially Italy and France, it is in frequent use.

Like emetic tartar, it has been administered with great benefit as a contra-stimulant or hyposthenic (see *ante*, p. 97) in inflammatory diseases, especially pneumonia.[1] The uncertainty of its operation is, however, a great drawback to its use; and even when it possesses activity, it is doubtful whether it has any advantages over emetic tartar. Some writers, however, assert that it is less irritating to the stomach and bowels: but assuming this to be true, it is probably referable to its inferior activity.

ADMINISTRATION.—Mineral kermes is given, in the form of powder or pill, in doses of from half a grain to two or three grains.

b. *Antimonii Tersulphuretum Præcipitatum.—Precipitated Tersulphuret of Antimony.*

All the British Colleges give directions for the preparation of an amorphous antimonial sulphuret, called by the London College *antimonii oxysulphuretum*; by the Edinburgh College, *antimonii sulphuretum aureum*; and by the Dublin College, *sulphur antimoniatum fuscum*.

The *London College* orders of Sesquisulphuret of Antimony, ℥vij.; Solution of Potash, Oiv.; Distilled Water, *Cong*. ij.; Diluted Sulphuric Acid, as much as may be sufficient. Mix the sesquisulphuret of antimony, solution of potash, and water together, and boil with a slow fire for two hours, frequently stirring, distilled water being often added, that it may fill about the same measure. Strain the liquor, and gradually pour into it as much diluted sulphuric acid as may be sufficient to precipitate the oxysulphuret of antimony; then, with water, wash away the sulphate of potash, and dry what remains with a gentle heat.

The *Edinburgh College* orders of Sulphuret of Antimony, in fine powder, ℥j.; Solution of Potash, f℥xj.; Water, Oij.

The *Dublin College* directs of Prepared Sulphuret of Antimony, *one part*; Water of Caustic Potash, *eighteen parts*; Diluted Sulphuric Acid, *eleven parts*, or as much as may be sufficient.

The *theory* of the process has been already in part explained. When the common black tersulphuret of antimony is boiled with a solution of caustic potash, sulphuret of potassium and teroxide of antimony are produced, $3KO + SbS^3 = 3KS + SbO^3$: the former combines with and dissolves some tersulphuret of antimony ($3KS + xSbS^3$), while the latter unites with potash ($KO + SbO^3$). Thus the solution contains hyposulphantimonite of potassium and hypantimonite of potash.

When sulphuric acid is added to the strained liquor, it decomposes the sulphuret of potassium, precipitates the tersulphuret of antimony, and combines with the potash which retained the teroxide of antimony in solution: the latter is wholly, or in great part, re-converted into tersulphuret of antimony. $4SO^3 + 3(KS,SbS^3) + KO,SbO^3 = 4(KO,SO^3) + 4SbS^3$. From Mr. Phillips's analysis it would appear that some teroxide of antimony escapes decomposition, and is contained in the precipitated product. It is probable that the precipitate sometimes contains pentasulphuret of antimony, SbS^5. This is formed by the action of atmospheric oxygen on the alkaline solution prior to the addition of the sulphuric acid. $2O + 3(KS,SbS^3) = 2KO + KS,SbS^5 + 2SbS^3$.

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[1] See Dr. Stack's *Medical Cases*, p. 9, 1784.

PROPERTIES.—Oxysulphuret of antimony is a red, odourless, almost tasteless powder. It is insoluble in cold water, and only slightly soluble in liquor ammoniæ. Boiled in nitro-hydrochloric acid, terchloride of antimony is formed in solution, and some sulphur remains undissolved. Heated in the air, it burns, evolves sulphurous acid, and leaves a greyish residuum.

Characteristics.—When heated with concentrated hydrochloric acid, it evolves hydrosulphuric acid, shewing it to be a sulphuret. From the other sulphurets or oxysulphurets of antimony it is to be distinguished partly by its colour. Its hydrochloric solution is shewn to contain antimony by the tests for this metal. When boiled in a solution of bitartrate of potash, a solution of emetic tartar is obtained, which may be recognised by the characters hereafter to be mentioned for this salt. It may be reduced by hydrogen and heat.

COMPOSITION.—By boiling in a solution of bitartrate of potash, it loses, according to Mr. Phillips, 12 per cent.—the amount of teroxide which it is presumed to contain.[1] Its composition, according to the same authority, is as follows:—

	Atoms.	*Eq. Wt.*	*Per Cent.*	*Phillips.*
Teroxide Antimony	1	153	13	12
Tersulphuret Antimony	5	885	75	76·5
Water	16	144	12	11·5
Oxysulphuret Antimony, *Ph. L.*	1	1182	100	100·0

By microscopic examination, I can discover no crystals of teroxide of antimony in samples of this compound made by Mr. R. Phillips and by myself.

From the mode of its preparation, this compound would appear to be a mixture of amorphous tersulphuret of antimony, SbS^3, with some pentasulphuret, SbS^5. In other words, it is probably a mixture of mineral kermes (minus the alkaline sulphuret) and golden sulphuret. According to the Edinburgh College, it is "a mixture or compound of sesquisulphuret of antimony, sesquioxide of antimony, and sulphur."

PURITY.—Recently precipitated oxysulphuret of antimony is readily and completely soluble in liquor potassæ: but the oxysulphuret of the shops leaves a white residuum. Boiled in hydrochloric acid, it is dissolved with the evolution of hydrosulphuric acid gas: the solution is opalescent or slightly milky, but becomes quite transparent on the addition of a small quantity of nitric acid. It should not effervesce with dilute sulphuric acid.

The *London College* states that it is

Totally soluble in nitro-hydrochloric acid, emitting hydrosulphuric acid.

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[1] This method of determining the quantity of teroxide of antimony cannot be absolutely relied on (see H. Rose, Poggendorff's *Annalen*, Bd. xlvii.)

But I find that it is not completely soluble in nitro-hydrochloric acid;—a portion of sulphur remaining behind.

The *Edinburgh College* states that it is

> "Tasteless: twelve times its weight of muriatic acid, aided by heat, will dissolve most of it, forming a colourless solution, and leaving a little sulphur."

The commercial oxysulphuret is of a brighter colour than that obtained according to the process of the Pharmacopœia. A manufacturer of it informs me that it is prepared by boiling sulphur along with the black sulphuret of antimony and potash, and precipitating by an acid in the usual way. Mr. Redwood[1] mentions two ways by which a product resembling the usual commercial article may be procured: one is by boiling together 4 parts of black sulphuret of antimony, 8 parts of lime, and 80 parts of water, and precipitating the strained solution by excess of hydrochloric acid; the other is by fusing together 2 parts of black sulphuret of antimony, 4 parts of carbonate of potash, and 1 part of sulphur, boiling the fused mass when cold in 20 times its weight of water, and precipitating by a large excess of dilute sulphuric acid.

PHYSIOLOGICAL EFFECTS.—The medicinal activity of this preparation is greater in proportion to the quantity of teroxide of antimony which it may contain (see *ante*, p. 686). The obvious effects are precisely analogous to those of emetic tartar; namely, vomiting, purging, and sweating. In small doses it is employed as an alterative, expectorant, and diaphoretic: in somewhat larger doses it causes nausea and sweating, and sometimes vomiting: in still larger quantities it excites both vomiting and purging.[2]

USE.—It is principally employed as an *alterative* in chronic diseases, particularly cutaneous affections, glandular enlargements, secondary syphilis, rheumatism, and diseases of the liver. In these complaints it is usually associated with mercurials (especially calomel), and sometimes with either guaiacum or narcotics.

ADMINISTRATION.—As an alterative the dose is from one to three or four grains: as an emetic from five grains to a scruple. It is a constituent of the *pilulæ hydrargyri chloridi compositæ*, commonly termed *Plummer's pill.*

ANTIDOTES.—Vide *Antimonii et Potassæ Tartras.*

105. Antimonii Pentasulphuretum.—Pentasulphuret of Antimony.

Formula SbS^5. *Equivalent Weight* 209.

Sulphur Antimonii Auratum; Golden Sulphuret of Antimony; Stibium Sulphuratum Aurantiacum.—Obtained by adding a diluted mineral acid (usually sulphuric acid) to the mother liquor from which mineral kermes has been deposited: the precipitate is to be washed and dried. Its formation has been before explained (see *ante*, p. 684). *Schlippe's salt* is the sulphantimoniate of sodium, $3NaS,SbS^5,18HO$. When it is decomposed by sulphuric acid, the golden sulphuret of antimony is precipitated. $3NaS,SbS^5,18HO+3SO^3=3(NaO,SO^3)+SbS^5+3HS+15HO$, Golden sulphuret of antimony is an orange-red, odourless, and tasteless powder. In its medicinal properties and uses it resembles mineral kermes and precipitated sulphuret of antimony (see *ante*, pp. 685). The dose is from half a grain to two or three grains.

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[1] Gray's *Supplement to the Pharmacopœia*, 2d edit. 1848.

[2] For some experiments and observations on the action of *Kermes Mineral* and the *Golden Sulphuret*, consult Rayer, in *Dict. de Méd. et Chir. Prat.* iii. 57, *et seq.*

106. ANTIMONII TERCHLORIDUM.—TERCHLORIDE OF ANTIMONY.

Formula $SbCl^3$. *Equivalent Weight* 235·5.

HISTORY.—Basil Valentine was acquainted with this preparation, which has had various appellations, such as *oil* or *butter of antimony* (*oleum* seu *butyrum antimonii*), *muriate* or *hydrochlorate of antimony, sesquichloride of antimony, protochloride of antimony,* &c.

PREPARATION.—There are several methods of obtaining terchloride of antimony, which, in the pure state, is not used in medicine.

The liquid sold in the shops and used in medicine under the name of *butter of antimony,* is a solution of terchloride of antimony in liquid hydrochloric acid. It is the *liquor stibii chlorati* of the Pharm. Bor., 1846. It is sometimes prepared by dissolving roasted antimony-ash (see *ante,* p. 675) in hydrochloric acid. It may also be prepared by dissolving the common crude antimony (SbS^3) in hydrochloric acid. The addition of a little nitric acid facilitates the process.

In the Prussian Pharmacopœia it is directed to be prepared by dissolving lbj. of powdered black sulphuret of antimony in lbiv. of crude hydrochloric solution. The filtered solution is to be evaporated to lbiss., and to the cold liquor ℥ix. of hydrochloric acid, and lbiss. of distilled water, are to be added, or so much that the filtered liquor shall have the sp. gr. of 1·345 to 1·350.

By the action of liquid hydrochloric acid on tersulphuret of antimony, we obtain terchloride of antimony, while sulphuretted hydrogen escapes. $SbS^3 + 3HCl = SbCl^3 + 3HS$. The terchloride of antimony thus obtained is dissolved in excess of liquid hydrochloric acid, forming the *hydrochloric solution of terchloride of antimony* (*liquor hydrochloricus antimonii teroxydi*).

If this solution be submitted to distillation, the water and excess of hydrochloric acid are first expelled; afterwards the terchloride is volatilized: this concretes on cooling. If, therefore, our object be to obtain the pure terchloride, it may be procured from the hydrochloric solution by changing the receiver as soon as the distilled product concretes on cooling.

In order to deepen the colour of the commercial butter of antimony, pernitrate of iron is usually added to it.

PROPERTIES.—The *butter of antimony* of the shops is a transparent liquid, varying in its colour from pale yellow to deep red. If it be free from iron, it is yellowish: the deep red colour of the article usually found in the shops is due to pernitrate of iron. Its sp. gr. varies from 1·2 to 1·5. The Prussian College fix it at from 1·345 to 1·350. It fumes in the air (especially when ammonia is present), in consequence of containing an excess of hydrochloric acid. It reacts on vegetable colours as a powerful acid.

Characteristics.—Mixed with water, it throws down a whitish powder (*oxichloride of antimony,* $SbCl^3,5SbO^3$). The hydrosulphurets produce a reddish precipitate (SbS^3), usually darkened by sulphuret of iron (FeS). Alkalies and their carbonates occasion a precipitate of the white teroxide of antimony (SbO^3), usually discoloured by sesquioxide of iron, Fe^2O^3. Nitrate of silver occasions a white precipitate ($AgCl$ and SbO^3).

COMPOSITION.—Terchloride of antimony is thus composed:—

	Atoms.	*Eq. Wt.*	*Per Cent.*	*Göbel.*	*H. Rose.*
Antimony	1	129	54·8	54·98	53·27
Chlorine	3	106·5	45·2	45·02	46·73
Terchloride of Antimony	1	235·5	100·0	100·00	100·00

The butter of antimony of the shops consists of *terchloride of antimony, free hydrochloric acid,* a little *nitrous acid, water,* and *sesquichloride of iron.* It may also contain other impurities derived from the tersulphuret from which it is prepared. Serullas says he never found arsenic in it.

PHYSIOLOGICAL EFFECTS.—It acts as an energetic caustic; but I am not acquainted with any cases of poisoning by it. It cannot be much diluted without undergoing decomposition.

USES.—In medicine it is employed only as a caustic. It usually acts without much pain or inflammation, and, after the separation of the eschar, produces a clean healthy surface. It is sometimes used as an application to parts bitten by rabid animals or venomous serpents; its liquidity enabling it to penetrate into all parts of the wound. It is also applied to ulcers to repress excessive granulations. Richter and Beer have employed it in staphyloma: the mode of applying it is as follows:—Dip a camel's hair pencil, or a point of lint, into the liquid, and apply it to the tumour until a whitish crust is perceived, when the whole is to be immediately washed away by means of a larger pencil dipped first into milk and afterwards into milk and water.

ANTIDOTES.—The treatment of poisoning by this preparation is the same as for the mineral acids (see *ante,* pp. 160 and 360). After the use of antacids, vegetable astringents (tea and infusion of nutgalls) should be administered to neutralize the effect of the oxichloride of antimony separated in the stomach.

107. ANTIMONII ET POTASSÆ TARTRAS.—TARTRATE OF ANTIMONY AND POTASH.

Formula $KO,SbO^3,C^8H^4O^{10},3HO$; or $KO,SbO^3,\bar{T},3HO$. *Equivalent Weight* 359.

HISTORY.—This salt was first publicly noticed in 1631 by Hadrian de Mynsicht.[1] "But the preparation was in all probability suggested by a treatise, entitled *Methodus in pulverem,* published in Italy in 1620. This book, written by Dr. Cornachinus, gives an account of the method of preparing a powder which had been invented by Dudley, Earl of Warwick, and which had acquired celebrity in Italy in consequence of the wonderful cures which it had performed. This powder was composed of scammony, sulphuret of antimony, and tartar, triturated together. The extraordinary effects which it produced would naturally draw the attention of chemists to the combination of antimonial preparations with tartar."[2]

This salt has had various denominations, such as *emetic* or *stibiated tartar* (*tartarus emeticus, antimoniatus,* vel *stibiatus*); *tartarized antimony* (*antimonium tartarizatum*); *potassio-tartrate of antimony* (*antimonii potassio-tartras*); *antimonio-tartrate of potash* (*potassæ antimonio-tartras*); *stibium oxydatum kalico-tartaricum; kali tartaricum stibiatum,* &c.

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[1] *Thesaurus Medico-Chymicus.*

[2] Thomson's *System of Chemistry,* 7th edit. vol. ii. p. 797, 1831.

PREPARATION.—Tartrate of antimony and potash is prepared by boiling water and cream of tartar with teroxide of antimony. $KO,\bar{T}+SbO^3+3HO=KO,SbO^3,\bar{T},3HO$.

Formerly, either saffron of antimony (*crocus antimonii*) or glass of antimony (*vitrum antimonii*) was employed to yield teroxide of antimony in the manufacture of emetic tartar. Antimony ash (*cinis antimonii*) is also sometimes used (see *ante*, p. 675). But probably the best method is to obtain teroxide of antimony by washing either oxichloride or subsulphate of antimony with an alkaline carbonate (see *ante*, p. 675).

If the teroxide of antimony be quite pure, the atomic proportions of this substance and of cream of tartar required to produce emetic tartar are—one equivalent, or 153 parts, of the teroxide, and one equivalent, or 188 parts, of the crystals of cream of tartar.

The *London Pharmacopœia* of 1836 gives the following directions for the preparation of this salt:—

Take of Sesquisulphuret of Antimony, rubbed to powder; Nitrate of Potash, powdered, each, lbij.; Bitartrate of Potash, powdered, ℥xiv.; Hydrochloric Acid, f℥iv.; Distilled Water, *cong.* j. Accurately mix the Sesquisulphuret of Antimony with the Nitrate of Potash; the Hydrochloric Acid being then added, and the powder spread upon iron plate, ignite it. Rub what remains to very fine powder, when it is cold, and wash it frequently with boiling water until it is free from taste. Mix the powder thus prepared with the Bitartrate of Potash, and boil for half an hour in a gallon of distilled water. Strain the liquor while hot, and set it aside that crystals may be formed. These being removed and dried, let the liquor again evaporate that it may yield crystals.

By the deflagration of the sulphuret of antimony with nitre, there are obtained sulphate of potash and teroxide of antimony, with some undecomposed sulphuret. The hydrochloric acid prevents the formation of potash and sulphuret of potassium, and gives rise to the formation of chloride of potassium. By washing, the sulphate and chloride are removed, and there remains teroxide of antimony mixed with some tersulphuret.

This process is inferior to that of the Edinburgh College.

The *Edinburgh College* gives the following directions for the preparation of this salt:—

Take of Sulphuret of Antimony, in fine powder, ℥iv.; Muriatic Acid (commercial) Oj.; Water, Ov. Dissolve the sulphuret in the acid with the aid of a gentle heat; boil for half an hour; filter; pour the liquid into the water; collect the precipitate on a calico filter, wash it with cold water till the water ceases to redden litmus paper; dry the precipitate over the vapour bath. Take of this precipitate, ℥iij.; Bitartrate of Potash, ℥iv. and ʒij.; Water, f℥xxvij. Mix the powders, add the water, boil for an hour, filter, and set the liquid aside to crystallize. The mother liquor, when concentrated, yields more crystals, but not so free of colour, and, therefore, requiring a second crystallization.

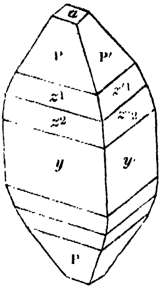
In this process terchloride of antimony, $SbCl^3$, is first obtained. By water, this is first converted into the oxichloride, $SbCl^3,5SbO^3$, which, by continued washing, is converted almost entirely into teroxide, SbO^3. This combines, in the subsequent part of the process, with the bitartrate, and forms emetic tartar.

This is an excellent process for the manufacture of emetic tartar.

The *Dublin College* orders Emetic Tartar to be prepared with Nitro-Muriatic Oxide of Antimony (Oxichloride, see p. 674), *four parts;* Bitartrate of Potash, triturated to a most subtile powder, *five parts;* Distilled Water, *thirty-four parts.*

PROPERTIES.—Emetic tartar crystallizes in white, transparent, inodorous, rhombic octohedrons, whose lateral planes are striated (see fig. 128). By ex-

FIG. 128.

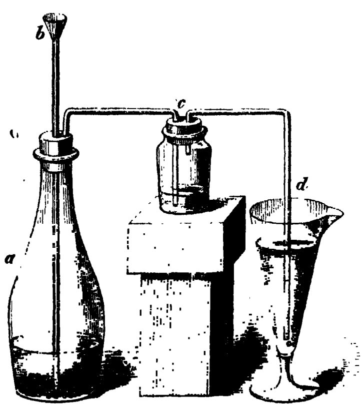


Octohedron of Emetic Tartar.

posure to the air the crystals become opaque, probably by giving out an equivalent of water. Their taste is feebly sweetish, then styptic and metallic. They dissolve in 14 or 15 parts of water at 60° F. (12$\frac{65}{100}$ at 70°, Brandes), and in two parts (2$\frac{78}{100}$ parts, Brandes) at 212°. The aqueous solution slightly reddens litmus. Emetic tartar is not soluble in alcohol. When calcined in close vessels, it yields a pyrophoric alloy of antimony and potassium. The crystals decrepitate in the fire.

Characteristics.—Heated in a porcelain or glass capsule, this salt is charred, and evolves the peculiar caramel-like odour of burning tartaric acid. If the charred salt be heated in a glass tube by a blowpipe, globules of antimony are obtained. If the reduction be effected on charcoal, a portion of the metal is re-oxidized, and deposited on the charcoal in the form of a white powder or crystalline needles (SbO^3).

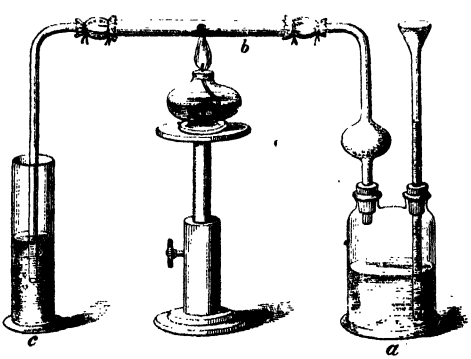
FIG. 129.



Apparatus for the passage of sulphuretted hydrogen through a solution of emetic tartar (see *ante*, p. 647).

If a stream of hydrosulphuric acid gas, generated in the flask *a*, fig. 129, be washed, by passing it through water contained in the bottle *c*, and then conveyed into a solution of emetic tartar slightly acidulated by hydrochloric acid, and contained in the glass *d*, an orange-red precipitate of amorphous tersulphuret of antimony (SbS^3) is obtained. This precipitate is soluble both in liquor ammoniæ and hydrochloric acid (see *ante*, p. 647). If it be collected, dried, introduced into a green glass tube, a current of hydrogen gas transmitted over it; and, when the process has gone on for a few minutes, the heat of a spirit-lamp applied to it, hydrosulphuric acid and metallic antimony are produced. ($SbS^3 + 3H = Sb + 3HS$). A portion of the metal is [spuriously ?] sublimed. The metal is known to be antimony by dissolving it in nitro-hydrochloric acid: the solution ($SbCl^3$) forms a white precipitate ($SbCl^3,5SbO^3$) on the addition of water, and an orange-red one (SbS^3) with hydrosulphuric acid gas or hydrosulphate of ammonia. The mode of reducing the ter-

FIG. 130.



Apparatus for reducing tersulphuret of antimony.

a, Vessel for generating hydrogen.
b, Reduction tube.
c, Vessel containing solution of acetate of lead to detect the hydrosulphuric acid which is formed.

sulphuret will be readily understood by the accompanying woodcut (fig. 130). This process was proposed by the late Dr. E. Turner.

If the solution of emetic tartar, which has been deprived of antimony by sulphuretted hydrogen, be filtered and evaporated, it yields crystals of cream of tartar,[1] $KO,\bar{T},HO$, the characters of which have been already pointed out (see *ante*, p. 519).

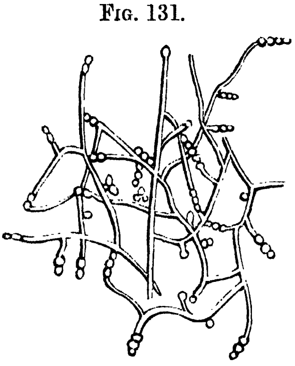
Hydrosulphuret of ammonia ($NH^3,2HS$) occasions, in a solution of emetic tartar, an orange-red precipitate (SbS^3), which is completely soluble in an excess of the precipitant.

Infusion of nutgalls occasions an abundant bulky whitish-yellow precipitate of tannate of antimony.

If emetic tartar be dissolved in water, and to the solution sulphuric acid and zinc be added, antimoniuretted hydrogen gas, SbH^3, is evolved. $SbO^3 + 6Zn + 6(HO,SO^3) = 6(ZnO,SO^3) + SbH^3 + 3HO$. The characters of this gas have been already pointed out (see *ante*, p. 651, *et seq.*)

A soft, flexible, mucilaginous mass forms in an aqueous solution of emetic tartar when kept for some time. If this be examined by the microscope, it is seen to consist of articulated filaments with branches which at the apex support a series of spermatia. This algaceous plant has been called by Kützing *Sirocrocis stibica* (fig. 131). But as the same plant is found in solutions of tartaric acid as well as of the tartrates generally, it might with propriety be termed *Sirocrocis tartarica*.[2]

FIG. 131.



Sirocrocis stibica, Kützing.

COMPOSITION.—The following is the composition of this salt:—

	Atoms.	*Eq. Wt.*	*Per Cent.*	*R. Phillips.*	*Thomson.*	*Wallquist.*
Teroxide of Antimony	1	153	42·619	43·35	42·62	42·99
Potash	1	47	13·091	49·25	57·38	13·26
Tartaric Acid	1	132	36·769			38·61
Water	3	27	7·521	7·40		5·14
Emetic Tartar	1	359	100·000	100·00	100·00	100·00

By many writers emetic tartar is assumed to contain only 2 eq. of water. $KO,SbO^3,\bar{T},2HO$.

PURITY.—In the crystalline state the purity of this salt is easily determined. The crystals should be well formed, perfectly colourless, transparent, or opaque, and, when dropped into a solution of hydrosulphuric acid, have an orange-coloured deposit (SbS^3) formed on them.

When pure, the powder of this salt is perfectly white. Some ignorant druggists prefer a yellowish-white powder; and I am informed by a manufacturer of this salt that he is obliged to keep two varieties (one white, the other yellowish white,) to meet the demands of his customers! The yellow tint is owing to the presence of iron, which is readily detected in the salt by the blue colour immediately produced in its solution by adding first a few drops of dilute sulphuric acid, and then ferrocyanide of potassium.

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[1] Thomson's *First Principles of Chemistry*, vol. ii. p. 441, 1825.

[2] *Pharmaceutical Journal*, vol. vii. pp. 343 and 370.

Emetic tartar is sometimes adulterated with bitartrate of potash. According to the late Mr. Hennell,[1] the antimonial salt may contain 10 per cent. of bitartrate, and yet the whole will dissolve in the proper quantity (14 or 15 parts) of water. In order to detect any uncombined bitartrate, he adds a few drops of a solution of carbonate of soda to a boiling solution of the antimonial salt, and if the precipitate formed be not dissolved, he concludes that there is no bitartrate of potash present.

A dilute solution of emetic tartar occasions no precipitate with chloride of barium: it produces a white precipitate (unless the solutions be very dilute) with nitrate of silver, and which is soluble in excess of water.

Totally soluble in water, no bitartrate of potash remaining in the vessel; and hydrosulphuric acid being added, a reddish coloured precipitate is obtained. Neither chloride of barium nor nitrate of silver being added to [a dilute] solution, precipitates anything. Nitric acid throws down a precipitate, which is dissolved by an excess of it.—*Ph. L.*

"Entirely soluble in twenty parts of water; solution colourless, and not affected by solution of ferrocyanide of potassium: a solution in forty parts of water is not affected by its own volume of a solution of eight parts of acetate of lead in thirty-two parts of water and fifteen parts of acetic acid."—*Ph. Ed.*

PHYSIOLOGICAL EFFECTS. α. *On Vegetables.*—Emetic tartar acts as a poison to plants.[2] The *Sirocrocis stibica*, however, grows luxuriantly in it (see *ante*, p. 693), and, therefore, forms an exception to this statement.

β. *On Animals.*—An extended examination of the effects of emetic tartar on the different classes of animals is still a desideratum. Hitherto experiments with it have been principally confined to dogs, rabbits, horses, oxen, sheep, and cats. Moiroud[3] has given two drachms to horses, and gradually increased the dose to six ounces, without perceiving any remarkable and permanent derangement in the exercise of the principal functions. Gilbert (quoted by Moiroud) has exhibited ten drachms to a cow, and four to a sheep, without any remarkable effect: but six drachms killed an animal of the latter species. Magendie[4] examined its effects on dogs. He found that from six to ten grains introduced into the stomach killed the animals in from two to three hours, when the gullet was tied: those who were able to get rid of it by vomiting took as much as a drachm without experiencing any bad effects, and in some cases half an ounce caused no ill effects. From his experiments it appears that it operates locally and by absorption, its principal action being on the intestinal canal and lungs; for nausea, vomiting, alvine evacuations, difficulty of respiration, and accelerated respiration, were produced by injecting a solution of the salt into the veins; by introducing it into the stomach, as well as by applying it in the solid state to the cellular tissue. Traces of pneumonia, gastritis, and enteritis, were found after death. These experiments have been repeated by Rayer and Bonnet[5] on rabbits, but without obtaining the lesion of the lungs mentioned by Magendie: in some cases no appreciable lesion was observed in any organ. Dr. Campbell (quoted by Dr. Christison) found no pulmonary inflammation in a cat killed by this salt. According to Flourens,[6] emetic tartar injected into the veins of ruminants causes efforts to vomit, but not actual vomiting; of the four stomachs possessed by these animals, the *reed* or true stomach is the only one affected by it. Orfila[1] has detected antimony in the viscera of animals to whom emetic tartar had been administered by the stomach. It has also been found in the blood and urine (see *ante*, pp. 101 and 102).

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[1] Phillips's *Transl. of the Pharm.* 4th edit.

[2] Schübler and Zeller, in *Schweigger's Journ. f. d. Chem.* 1827, B. 50, S. 54-66.

[3] *Pharm. Vétér.* 287.

[4] Orfila, *Toxicol. Gén.*

[5] *Dict. de Méd. et de Chir. Prat.* iii. 69.

[6] *Mémoires de l'Academie Royale des Sciences*, t. xvi. 1838; also, *Journ. de Chim. Méd.* ix. 21.

γ. *On Man.* αα. *Local effects.*—Emetic tartar is a powerful local irritant. Its irritant properties may be regarded as of a peculiar or specific kind; at least if we are to judge from its well-known effects when applied to the epidermis (as in the form of solution or ointment, or sprinkled over a plaster). It causes an eruption of painful pustules, resembling those of variola or ecthyma. The smaller ones are semi-globular; the larger ones, when at their height, are flattened, are surrounded with an inflammatory border, contain a pseudo-membranous deposit and some purulent serum, and have a central dark point. When they have attained their greatest magnitude, the central brown spots become larger and darker, and, in a few days, desiccation takes place, and the crusts are thrown off. The largest are produced by using the powder sprinkled over a plaster; the smallest are developed by applying the solution. They are usually very painful. I am acquainted with no agent which produces an eruption precisely like that caused by emetic tartar. The facility with which it is produced varies considerably in different individuals, and in the same individual at different times.

A pustular eruption has been met with in the mouth, œsophagus, and small intestines, from the internal use of emetic tartar, and white aphthous spots have been observed on the velum and tonsils.[2] But these effects are rare. Severe inflammation of the throat (*angina antimonialis?*) has sometimes followed the employment of antimony.[3]

We have further evidence of the local irritation produced by emetic tartar in its action on the stomach and intestines. When swallowed in full doses, it gives rise to vomiting and purging, and pain in the epigastric region. After death, redness of the gastro-intestinal membrane has been found. However, it would appear from the experiments of Magendie, before referred to, that part of this effect should be referred to the specific influence which this salt exerts over the stomach, independent of its direct local irritation, since the same symptoms have been induced by its application to wounds, and by its injection into the veins.

Occasionally, constitutional effects (nausea, vomiting, and griping pains) have appeared to result from its application to the skin.[4] In one instance death resulted from its employment: the patient was an infant two years of age, and death occurred in forty-eight hours.[5] These effects, if really produced by this salt, occur very rarely. I have applied to the skin emetic tartar (in the form of solution, ointment, and plaster) in a very large number of cases, without having observed any constitutional effect; though I have occasionally fancied that it ameliorated pulmonary affections, even when no eruption or redness was produced, and which might arise from absorption.[6]

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[1] *Journ. de Chim. Méd.* t. vi. IIe Série, p. 290. See also the Report of the Commissioners of the French Academy of Sciences, in the *Journ. de Pharm.* xxvii. p. 415.

[2] Lepelletier, *De l'Emploi du Tart. Stibié*, p. 171, Paris, 1835.

[3] *Lond. Med. Gaz.* March 20, 1840, p. 960.

[4] *Journ. de Chimie Méd.* iv. 478.

[5] *Med. Repos.* xvi. 357.

[6] See also some experiments on this subject in *Mem. of the Med. Soc. Lond.* vols. ii. iv. and v.

ββ. *Remote* or *constitutional effects.*—Taken internally, *in small doses*, emetic tartar increases the secretion and exhalation of the gastro-intestinal membrane, and of the liver and pancreas. Subsequently it acts powerfully on other emunctories: thus it causes sweating, without any very marked vascular excitement; it renders the mucous membranes (especially the aërian membrane) moister, and, when the skin is kept cool, promotes the secretion of urine. These effects are produced more certainly and speedily by this salt than by any other antimonial preparation.

In somewhat larger doses it excites nausea, frequently with vomiting, disorders the digestive functions, gives rise to an uneasy sensation in the abdominal region, depresses the nervous functions, relaxes the tissues (especially the muscular fibres), and occasions a feeling of great feebleness and exhaustion. These symptoms are accompanied or followed by increased secretion and exhalation from the different emunctories, but especially from the skin, as above mentioned. Of all emetic substances, this creates the most nausea and depression.

In excessive doses, emetic tartar has, in a few instances, acted as an irritant poison, and even occasioned death. In one case a scruple, in another 27 grains, nearly proved fatal.[1] In a third, 40 grains caused death.[2] The symptoms in the latter case were vomiting, hypercatharsis, convulsions, epigastric pain and tumefaction, and delirium. Death occurred four days after the ingestion of the poison.

Were the above cases not well authenticated, we should be disposed to ascribe the dangerous symptoms, and death, to some other circumstance rather than to the use of the above-mentioned quantities of emetic tartar; for of late years this salt has been extensively employed in enormous and repeated doses with perfect safety. Rasori[3] has given many drachms in twenty-four hours, and many ounces during the course of a disease, without occasioning either vomiting or abundant alvine evacuations. Laennec[4] has confirmed, to a certain extent, the statements of Rasori. He gave a scruple, two scruples, and even a drachm and a half, within twenty-four hours (usually in doses of one, two, or three grains) without ever having seen any injurious consequences. The usual effects which I have observed from the continued use of one or two grain doses, are nausea, vomiting, and purging, which in most cases are much diminished, or entirely cease, after the use of the medicine for a day or two. Perspiration I have found to be a frequent effect. In all the instances above referred to, in which these large doses were administered, the patients were affected with inflammatory diseases. Now it is to this morbid state, or *diathesis*, that, according to Rasori, we ought to ascribe the *tolerance* of, or capability or *aptitude* of bearing, these immense quantities of this powerful medicine (see *ante*, p. 96, *et seq.* for some remarks on the Italian *doctrine of contra-stimulus*). Consequently, if the opinion be worth any thing, the susceptibility to its influence should increase as the disease subsides,—a circumstance which Rasori asserts really takes place. But in this the theoretical views of this distinguished Italian have probably led him to overlook the truth. "It is certainly true," observes Laennec, "that after the acute period of the disease [peripneumonia], the tolerance diminishes, or sometimes entirely ceases; but it is more common to find the patient become habituated to the medicine, insomuch that during convalescence, and when he has begun to use food as in health, he will take daily, without knowing it, six, nine, twelve, or even eighteen grains of the emetic tartar." Though I have seen this salt extensively employed in both public and private practice, I have never met any satisfactory cases supporting Rasori's assertion of the diminished tolerance when the patient becomes convalescent. Moreover, large doses have been taken by healthy individuals without any remarkable effects. Alibert[1] saw, at the Hôpital St. Louis, a man who took a drachm of this salt in order to poison himself, but suffered no remarkable inconvenience from it. Lebreton[2] reports the case of a girl who swallowed six drachms at once as a poison: oil was immediately given; vomiting took place, and she soon recovered. Other published cases might be brought forward in proof of the slight effects of large doses, but I must content myself with referring to the memoir of Magendie[3] for a notice of them. I may add, however, that this distinguished physiologist concludes, that the comparative slightness of the effects arose from the evacuation of the salt a few moments after its ingestion; though in several, at least, of the cases, this was not proved, and in one it certainly did not happen: it was that of a man who swallowed 27 grains of this salt, and did not vomit.

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[1] Orfila, *Toxicol. Générale.*

[2] *Ibid.*

[3] Bayle's *Bibliothèq. de Thérap.* i. 198.

[4] *Treatise on Diseases of the Chest*, by Dr. Forbes, p. 249.

The action of large doses of emetic tartar on the circulation and respiration is usually that of a sedative. This has been very frequently, though not constantly, observed. In one case of peripneumonia, the daily use of from six to eight grains reduced the pulse, in nine days, from 120 to 34 beats per minute, and diminished the number of inspirations from 50 to 18.[4] In another, the pulse descended, in three days, from 72 to 44 beats per minute.[5]

MODUS OPERANDI.—Emetic tartar, when swallowed, becomes absorbed, and may be detected in the blood and viscera, especially the liver. It is eliminated by the urine, in which secretion it can readily be recognised. Minaret[6] states, that a young woman labouring under pleuritis took emetic tartar, which operated on the child at her breast as well as on herself. It therefore probably existed in the milk.

Several parts of the body are influenced by this salt. The specific affection of the *alimentary canal* (especially of the stomach) is shown by the vomiting[7] and purging produced, not only when the medicine is swallowed, but when it is injected into the veins or into the windpipe, or when applied to the serous coats of the intestines, or to the cellular tissue. If it purge, or occasion sweating, it usually causes thirst, but not commonly otherwise. The appetite and digestion are frequently unimpaired. After the use of it for some days, patients sometimes complain of irritation in the mouth and throat, with a metallic taste: this has been considered a sign that the system is saturated with antimony, and that the use of it should be suspended. A pustular eruption has occasionally appeared in the mouth, as I have already stated.

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[1] *Nouv. Elém. de Thérap.* 5me édit. i. 259.

[2] Orfila, *Toxicol. Gén.*

[3] *De l'Influence de l'Emetique.*

[4] Bouneau et Constant, quoted by Lepelletier, *De l'Emploi du Tart. Stib.* 84.

[5] Trousseau, quoted by Lepelletier.

[6] *Lond. Med. Gaz.* xiii. 496.

[7] For some observations on the mode by which this salt induces vomiting, see p. 239.

Magendie ascribes to emetic tartar a specific power of causing engorgement or inflammation of the *lungs;* for he found, on opening the bodies of animals killed by it, that the lungs were of an orange-red or violet colour, incapable of crepitating, gorged with blood, and here and there hepatized. Moreover, it has been assumed that the same effects are produced in the human pulmonary organs; and in support of this opinion, a case noticed by Jules Cloquet[1] has been referred to: it is that of a man who died of apoplexy, but who, within five days of his death, had taken 40 grains of tartar emetic. "In the lungs were observed very irregular blackish spots, which extended more or less deeply into the parenchyma of this organ." Furthermore, it is argued, that unless we admit a specific influence of antimony over the lungs, we cannot well explain the beneficial effects of this remedy in peripneumonia. In opposition to this view I may remark, that in cases of poisoning by this substance in the human subject, no mention is made of difficulty of breathing, cough, pain, or other symptom, which could lead to the suspicion that the lungs were suffering; and in the case of poisoning related by Recamier,[2] we are distinctly told that the thorax was sound. Besides, we should expect that if emetic tartar had a tendency to inflame the lungs, or at least to occasion pulmonary engorgement, that large doses of it would not be very beneficial in acute peripneumonia. It would even seem that this substance must have an influence over the human lungs of an opposite kind to that supposed by Magendie; for, as already related, it reduces the frequency of respiration in a considerable number of instances.

The sedative influence of emetic tartar over the *circulatory system* has been already noticed.

The great depression of the muscular power, the diminution of the frequency of the pulse and fainting, the epigastric pain sometimes experienced under circumstances that almost preclude the supposition of gastric inflammation, the cramps and convulsions, the delirium and insensibility, caused by emetic tartar in poisonous doses, are referrible to the influence of this substance over the *nervous system.*

The *absorbent system* is supposed to be stimulated to greater activity by emetic tartar, in consequence of the disappearance of serous and synovial effusions under its use. Moreover, Laennec[3] ascribed the efficacy of it in peripneumonia to the increased activity of the interstitial absorption.[4]

The influence of it over the *secreting organs* has been before referred to.[5] Every one is familiar with its diaphoretic properties. Its diuretic effect is best seen when the skin is kept cool, and when neither vomiting nor purging supervene. Magendie says, it augmented the secretion of saliva in dogs; and the same effect has been observed in man by Drs. Griffith and Jackson. The menstrual discharge is not checked by it; but occasionally has come on under its use.

Uses.—As an *emetic,* this salt is usually administered by the stomach, but it is sometimes used as an enema, and occasionally is injected into the veins. When administered by the stomach, it is generally given in doses of one or two grains, frequently in combination with ten or fifteen grains of ipecacuanha. When our object is merely to evacuate the contents of the stomach, and with as little constitutional disorder as possible (as in cases of narcotic poisoning), other emetics (as the sulphates of zinc and copper) are to be preferred, since they occasion less nausea and depression of system, while they excite speedy vomiting. On the other hand, when we use vomiting as a means of making an impression on the system, and thereby of putting a sudden stop to the progress of a disease, emetic tartar is by far our best vomit. It is with this view that it is sometimes employed in the early stages of fever, especially when accompanied by gastric or bilious disorder. Emetic tartar is used as a vomit, with considerable success, in the early stage of inflammatory diseases; especially in croup, tonsillitis, swelled testicle, bubo, and ophthalmia. Here, also, the success of the remedy is in proportion to its early application. In croup it should be given to excite in the first instance vomiting, and afterwards prolonged nausea. Under this plan of treatment I have seen two or three slight cases completely recover without the use of any other remedial agent. Dr. Copland[1] also bears testimony to the success of the practice. In most cases it will be found advisable to precede the use of this medicine by blood-letting. Dr. Cheyne[2] advises the employment of emetic tartar in the second stage of croup, for the purpose of moderating vascular action, and of promoting the separation of the adventitious membrane. But I am disposed to rely chiefly on calomel (given so as speedily to occasion ptyalism) and blood-letting. Dr. Cheyne recommends half a grain of emetic tartar to be dissolved in a table-spoonful of water, and given to a child two or three years of age, every half hour till sickness and vomiting are produced; and, in two hours after the last act of vomiting, the same process is to be recommenced, and so repeated while the strength will admit. Another disease which is relieved by the occasional use of emetics is *hooping-cough*. They should be administered at the commencement of the disease, every, or every other day. They diminish the violence and length of the fits of spasmodic coughing, and promote expectoration. Emetic tartar is particularly valuable in this disease in consequence of being tasteless, and, therefore, peculiarly adapted for exhibition to children. In derangements of the hepatic functions, indicating the employment of emetics, this salt is usually preferred to other vomiting agents, on account of its supposed influence in promoting the secretion of bile.

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[1] Orfila, *Toxicol. Générale.*

[2] Orfila, *op. cit.*

[3] *Op. cit.* p. 203.

[4] I have already made some observations on the mode by which resolvents operate, see p. 175.

[5] See *Liquefacientia,* pp. 175 and 184.

Clysters containing emetic tartar have been employed to occasion vomiting, but they are very uncertain in their operation. Rayer has frequently employed from six to twelve grains without producing either nausea or vomiting.

It has been repeatedly *injected into the veins* to excite vomiting. The usual dose is two or three grains dissolved in two ounces of water; but in some cases six grains have been employed. The effects are unequal: when vomiting does occur it is not always immediate; frequently it does not take place at all.[3] In several cases of choking, from the lodgment of pieces of meat in the œsophagus, this remedy has been applied with great success: vomiting was produced, and with it the expulsion of the meat. It has also been tried in epilepsy and trismus; but frequently with dangerous consequences.[1] Meckel employed it to restore animation in asphyxia by drowning.[2] It has also been used in tetanus.[3]

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[1] *Dict. of Pract. Med.* i. 467.

[2] *Essay on Cynanche Trachealis*, 1801.

[3] Dieffenbach, *Transf. d. Blut. u. d. Infus. d. Arzn.*

As a *nauseant*, to reduce the force of the circulation and the muscular power, emetic tartar is frequently of considerable service. Thus, in dislocations of the larger joints (the hip and shoulder, for example), blood-letting, and nauseating doses of emetic tartar, are employed to diminish the resistance of the muscles opposing the reduction. Even in strangulated hernia it has been given.[4]

Emetic tartar, in large doses, is a most powerful and valuable remedy in the treatment of inflammation. On this subject I have already offered some remarks (see *ante*, pp. 184 and 185.) As an emetic, nauseant, or diaphoretic, it has long been in use in peripneumonia; having been employed by Riverius in the 17th century, and subsequently by Stoll, Brendel, Schroeder, and Richter, in Germany; by Pringle, Cullen, and Marryat, in England. But as a remedy for inflammation, independent of its evacuant effects, we are indebted for it to Rasori,[5] who first used it in the years 1799 and 1800, in an epidemic fever which raged at Genoa. Subsequently he exhibited it much more extensively, and in larger doses, in peripneumonia. This mode of treatment was tried and adopted in France, first by Laennec;[6] and in this country by Dr. Balfour.[7] Its value as an antiphlogistic is now almost universally admitted. Practitioners, however, are not quite agreed as to the best method of using it. Rasori,[8] Laennec,[9] Recamier,[10] Broussais,[11] Bouillaud,[12] Dr. Mackintosh,[13] Drs. Graves and Stokes,[14] Dr. Davies,[15] and most practitioners of this country, employ blood-letting in peripneumonia, in conjunction with the use of emetic tartar. But by several continental physicians the abstraction of blood is considered both unnecessary and hurtful. Thus Peschier[16] advises on no account to draw blood; and Trousseau[17] observes, that blood-letting, far from aiding the action of emetic tartar, as Rasori, Laennec, and most practitioners, imagine, is, on the contrary, singularly injurious to the antiphlogistic influence of this medicine. Louis[18] has published some numerical results of the treatment of inflammation of the lungs by blood-letting and by emetic tartar; from which it appears that this substance, given in large doses, where blood-letting appeared to have no effect, had a favourable action, and appeared to diminish the mortality.[19] But he particularly states that blood-letting must not be omitted (p. 32).

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[1] Dieffenbach, *Transf. d. Blut. u. d. Infus. d. Arzn.* p. 49.

[2] *Ibid.*

[3] *Lancet* for 1836-37, vol. i. p. 35.

[4] *Ibid.* p. 876.

[5] See the French translation of his Memoir, in Bayle's *Biblioth. de Thérap.* i. 198.

[6] *Treatise on Diseases of the Chest*, translated by Dr. Forbes.

[7] *Illustrations of the Power of Emetic Tartar*, 2d edit. 1819.

[8] *Op. cit.*

[9] *Op. cit.*

[10] *Gazette Médicale*, 1832, p. 503.

[11] *Cours de Pathologie et de Thérapeutique générale*, ii. 521.

[12] *Dictionnaire de Médecine et de Chirurgie pratique*, xiii. 495.

[13] *Practice of Physic*, i. 426.

[14] *Dublin Hospital Reports*, v. p. 48.

[15] *Lectures on Diseases of the Lungs and Heart*, 188.

[16] Bayle, *Bibliothèque Thérapeutique*, i. 246.

[17] *Dictionnaire de Médecine*, 2e édit. iii. 220.

[18] *Recherches de la Saignée*, Paris, 1835.

[19] *Op. cit.* p. 62.

Laennec's mode of using this salt, and which, with some slight modification, I believe to be the best, is the following:—Immediately after bleeding, give one grain of emetic tartar, dissolved in two ounces and a half of some mild fluid [cold weak infusion of orange flowers], sweetened with half an ounce of syrup of marshmallows: this is to be repeated every two hours for six times, and then suspended for seven or eight hours, if the symptoms are not urgent, or if there be any inclination to sleep. But if the disease has already made progress, or if the oppression be great, or the head affected, continue the medicine until amendment takes place; and in severe cases increase the dose to two, or two and a half grains. The only modification in this plan, which I would venture to propose, is, to begin with a somewhat smaller dose (say one-third or one-half of a grain), and gradually increase it; for in consequence of the violent vomiting which one grain has sometimes produced, I have found patients positively refuse to continue the use of the medicine.

From my own experience I should say, that emetic tartar is nearly as serviceable when it causes moderate sickness and slight purging, as when it occasions no evacuation. Laennec observes, that "in general the effect of emetic tartar is never more rapid, or more efficient, than when it gives rise to no evacuation; sometimes, however, its salutary operation is accompanied by a general perspiration. Although copious vomiting and purging are by no means desirable, on account of the debility and hurtful irritation of the intestinal canal which they may occasion, I have obtained remarkable cures in cases in which such evacuations had been very copious."[1] A few drops of tincture of opium may be sometimes conjoined with the antimony, to check its action on the alimentary canal.

The attempts which have been made to explain the *modus medendi* of emetic tartar in pneumonia and other inflammatory diseases, are most unsatisfactory. Whilst almost every writer, even Broussais, admits its efficacy in inflammation, scarcely two agree in the view taken of the mode by which its good effects are produced, as the following statement proves:—Rasori explains its operation according to the principles of the theory of contra-stimulus,[2] of which he may be regarded as the founder. He considers emetic tartar endowed with the power of directly diminishing the inflammatory stimulus; of destroying the diathesis, and of being, therefore, a real contra-stimulus. Broussais, Bouillaud, and Barbier, ascribe its curative powers to its revulsive or derivative action on the gastro-intestinal membrane. Laennec thinks that it acts by increasing the activity of interstitial absorption. Fontaneilles supposes that the antiphlogistic effect depends on alterations in the composition of the blood. Eberle[3] refers it to the sedative effects, first, on the nervous system, and consecutively on the heart and arteries. Teallier thinks that, like many other therapeutic agents, it influences the organism by concealed curative properties. Dr. Macartney[4] regards it as a medicine diminishing the force of the circulation, by the nausea which it occasions. These examples are sufficient to show the unsatisfactory condition of our present knowledge as to the mode by which emetic tartar produces its curative effects.[5] But this is no argument against the existence of remedial powers. Shall we deny the efficacy of blood-letting in inflammation, of mercury in syphilis, of cinchona in intermittents, of arsenic in lepra, of sulphur in scabies, of hydrocyanic acid in gastrodynia, and of a host of other remedies, simply because we cannot account for their beneficial effects? The fact is, that in the present state of our knowledge we cannot explain the *modus medendi* of a large number of our best and most certain remedial means. (I have already offered some remarks on the modus medendi of liquefacients and resolvents, at pp. 175 and 176.)

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[1] *Op. supra cit.* p. 251.

[2] See *ante*, p. 96, et seq.

[3] *Materia Medica*, i. 66.

[4] *A Treatise on Inflammation*, 1838.

[5] See p. 175 for some observations on the curative agency of resolvents.

In *pleurisy* emetic tartar does not succeed so well as in inflammation of the substance of the lungs. "It, indeed, reduces speedily the inflammatory action," says Laennec,[1] "but when the fever and pain have ceased, the effusion does not always disappear more rapidly under the use of tartar emetic than without it." I have sometimes conjoined opium (always after copious blood-letting) with advantage. In *bronchitis* (both acute and chronic) it may be most usefully employed in conjunction with the usual antiphlogistic agents.[2] In *rheumatism* (especially the kind called *articular*), next to peripneumonia, emetic tartar has been found by some practitioners (especially by Laennec),[3] more efficacious than in any other inflammatory affection: the usual duration of the complaint, when treated by this remedy, was found by Laennec to be seven or eight days.[4] In muscular rheumatism it succeeds less perfectly. Synovial effusions (whether rheumatic or otherwise) have, in some cases, given way rapidly to the use of emetic tartar.[5] In *arachnitis*, Laennec has seen all the symptoms disappear, under the use of emetic tartar, in forty-eight hours. In three instances of acute hydrocephalus, all the symptoms disappeared in the same space of time. In *phlebitis*;[6] in *inflammation of the mammæ*, occurring after delivery;[7] in *ophthalmia*, and various other inflammatory affections, emetic tartar has been successfully employed as an antiphlogistic.

In continued fever, it is of considerable service. Mild cases are benefitted by the use of small doses (as from one-sixteenth to one-fourth of a grain) as a diaphoretic. In the more severe form of this disease, accompanied with much vascular excitement, emetic tartar, in the dose of half a grain or a grain, may be usefully administered as an antiphlogistic; but its use should, in general, be preceded by blood-letting. In the advanced stages of typhus-fever, accompanied with intense cerebral excitement, manifested by loss of sleep, delirium, &c., Dr. Graves[8] has obtained most beneficial results from the use of emetic tartar and opium. The same combination has been employed with great success in delirium tremens, as well as in delirium of erysipelas, scarlatina, and measles, by Dr. Law.[9]

Dr. Billing[10] regards Asiatic cholera as being "like ague; not merely as regards its epidemic and miasmatic origin, but almost, if not altogether, an ague of a fresh type;" and he depends much, in the treatment of it, on tartarized antimony with sulphate of magnesia. In a case of blue cholera he ordered two grains of emetic tartar and half an ounce of sulphate of magnesia in half a pint of water; a tablespoonful to be taken every half hour. The patient recovered.

Emetic tartar is one of our most valuable sudorifics, being oftentimes available when other agents of this class are inadmissible: for example, when we are desirous of producing diaphoresis, in fevers and other diseases which are accompanied with preternatural vascular action about the head, the use of opiate sudorifics (as the compound ipecacuanha powder) is objectionable; whereas emetic tartar may be employed with safety, since it has no tendency to increase disorder of the nervous system, but to reduce cerebral excitement. On the other hand, when much gastric or intestinal irritation is present, the narcotic sudorifics are generally to be preferred to antimony.

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[1] *Op. cit.* p. 259.

[2] *Vide* also Dr. Kemp, *Lond. Med. Gaz.* xix. 300; and Mr. Ellis, *op. cit.* p. 369.

[3] *Op. cit.*

[4] See also Bayle's *Bibl. Thérap.* i. 311; and Lepelletier, *De l'Emploi du Tart. Stib.* p. 220.

[5] Laennec, *op. cit.* p. 263; and Gimelle, *Brit. and For. Med. Rev.* for July 1838, p. 224.

[6] Laennec, *op. cit.*

[7] Dr. E. Kennedy, Mr. Lever, and Dr. Ashwell, *Lond. Med. Gaz.* xx. 761.

[8] *Lond. Med. Gaz.* xx. 538.

[9] *Ibid.* xviii. 538 and 694.

[10] *First Principles of Medicine*, p. 240, et seq. 4th edit. 1841.

As an expectorant, in various pulmonary affections, small doses of this salt are frequently employed with advantage.

In some spasmodic complaints the use of it has been followed, in the few instances in which it has been tried, with good effects.[1] In *apoplexy* it has been employed to depress cerebral vascular action, but its tendency to occasion vomiting renders it objectionable.

The internal employment of emetic tartar in syphilis has been recently advocated by Mr. Smee.[2]

As a local irritant, applied to the skin, it may be employed in the form of aqueous solution, ointment, or plaster. It is used in the same case as vesicatories, over which it has the advantage of not affecting the urino-genital organs. When it is desirable to keep up long-continued irritation, blisters are in some cases preferable. In *chronic diseases of the chest* it is used with the greatest advantage. I have found it much more serviceable than blisters. I frequently direct one part of the chest to be rubbed until the eruption is produced; and then, after the interval of a day or two, another part; thus keeping up irritation by a succession of applications to different parts of the chest for several months. In this way it is most serviceable in chronic catarrhs, peripneumonies, and pleurisies. Even in lingering phthisis I have seen the cough and pain alleviated by the occasional use of antimonial frictions. The objections to its use is the painful character of the eruptions. In *hooping-cough* it is also serviceable. Autenrieth recommended it as a means of diminishing the frequency of the paroxysms and the violence of the cough. In *laryngitis* it is occasionally of great service; as also in various *affections of the joints,* especially chronic inflammation of the capsular ligament, or of the synovial membrane, hydrops articuli, particularly when connected with inflammation, and tumors of various kinds about the joints. In *tic douloureux*[3] it has also been employed with benefit. In the *paralysis* of children the region of the spine should be rubbed with the ointment. Its effects are most beneficial, especially when one leg only is affected. It is sometimes necessary to keep an eruption out for many weeks. In *hysteria*[4] the same application to the spine has been found serviceable.

A *stimulating wash,* composed of one scruple of tartar emetic to an ounce of water, was proposed by the late Sir William Blizard, in the year 1787, to cleanse foul ulcers, repress fungous growths and venereal warts, and as an application to tinea capitis. A weak solution (as half a grain to the ounce of water) has been employed as a stimulant in chronic ophthalmia, and in spots on the cornea.

ADMINISTRATION.—The dose of emetic tartar, *in substance,* is, as a diaphoretic and expectorant, $\frac{1}{12}$ to $\frac{1}{6}$ of a grain; as a nauseant, from $\frac{1}{4}$ to $\frac{1}{2}$ a grain; as an emetic, from 1 to 2 grains; as an antiphologistic, from ½ a grain to 3 or 4 grains. This salt is, however, rarely employed in substance. Sometimes a grain of it, mixed with ten or fifteen grains of powdered ipecacuanha, is employed as an emetic. A mixture of one grain with sixteen grains of sulphate of potash may be employed, in doses of from two to four grains, as a substitute for antimonial powder, to promote diaphoresis.

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[1] *Vide* Laennec, *op. cit.* p. 260; Jacobi, *Lond. Med. Gaz.* iii. 784; and Mr. Ackerley, *Lond. Med. Gaz.* xxi. 56.

[2] *Lond. Med. Gaz.* vol. xxxi. p. 44, Oct. 7, 1842.

[3] Hausbrandt, *British and Foreign Medical Review,* Jan. 1837, 230.

[4] Tate, *A Treatise on Hysteria,* Lond. 1830.

In *solution*, it is commonly employed as an expectorant, diaphoretic, nauseant, or emetic, in the form of antimonial wine. When used as an antiphlogistic, an aqueous solution of greater strength may be administered: it should be made with boiling distilled water in a glass vessel (as a Florence flask).

For external use, emetic tartar is employed in the form of *liniment*, *ointment*, or *plaster*. A saturated solution is a very useful liniment: it is prepared by pouring an ounce and a half of boiling water over a drachm of emetic tartar, and allowing the solution to stand till cold. In many cases it will be found preferable to the ointment; being the mildest, least painful, and cleanest. Another mode of employing emetic tartar externally is by sprinkling from ten grains to a drachm of the salt in fine powder over a Burgundy pitch plaster.

ANTIDOTE.—Promote vomiting by tepid bland liquids. The antidote is said to be tannic acid, and vegetable substances which contain it (as yellow bark, tea, nutgalls, &c.) Faure[1] recommends the decoction in preference to other preparations of yellow bark. But though cinchona decomposes emetic tartar it does not destroy its activity. Some years since, at the General Dispensary, I saw from 1 to 2 grains of this salt, mixed with either powder or decoction of yellow bark, given by Dr. Clutterbuck to nearly 100 patients: and in almost every instance nausea and vomiting occurred. The experience of Laennec,[2] as well as of Rayer,[3] is to the same effect. Opium is a most valuable agent for checking excessive evacuations. Venesection and the warm bath have been used to relieve the gastro-enteritis.

1. VINUM ANTIMONII POTASSIO-TARTRATIS, L.; *Vinum Antimoniale*, E.; *Liquor Tartari Emetici*, D.; *Antimonial Wine*. (Emetic Tartar, ℈ij; Sherry, Oj., *L. E.*—Emetic Tartar, ℈j.; Hot distilled Water, f℥viij.; Rectified Spirit of Wine, f℥ij.)—Each fluidounce contains two grains of emetic tartar. It is important that Sherry, and not an inferior kind of wine, be employed: for the latter frequently contains matters which precipitate the teroxide of antimony. If the wine be good, and the salt pure, no precipitate is formed in the solution, unless it be kept for a long period, when decomposition of the salt ensues. The Dublin formula is objectionable on account of its want of colour.

Antimonial wine is used, as a diaphoretic or expectorant, in doses of from ten to thirty drops frequently repeated; as a nauseant, from one to two fluiddrachms; as an emetic, about half a fluidounce, or two fluidrachms given at intervals of about ten minutes for four or five times, until the desired effect is produced: as an emetic for children, from thirty drops to a fluidrachm; and as an antiphlogistic in peripneumonia, from two or three fluidrachms to an ounce; but for this latter purpose an extemporaneous but carefully made aqueous solution is to be preferred.

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[1] *Lond. Med. Gaz.* xvi. 703.

[2] *Diseases of the Chest*, Forbes's translation, 257.

[3] *Dict. de Méd. et Chir. Prat.* iii. 57.

2. **UNGUENTUM ANTIMONII POTASSIO-TARTRATIS**, L.; *Unguentum Antimoniale*, E.; *Unguentum Tartari Emetici*, D.; *Tartar Emetic Ointment*. (Emetic Tartar, rubbed to very fine powder, ʒj.; Lard, ℥iv., *L. E.*—The *Dublin College* orders ʒj. of the Emetic Tartar to ℥j. of Lard).—In the preparation of this ointment it is important that the emetic tartar be in the state of a very fine powder, in order to avoid the irritation produced by rubbing gritty particles on the skin. A portion of ointment about the size of a small nut is to be rubbed on the skin night and morning. After the use of it for two or three times, the painful condition of the part thereby induced commonly prevents further employment of friction. It is sometimes applied, spread on linen, without rubbing. By either of these methods a crop of painful pustules is produced: but the facility and rapidity with which they are developed varies considerably in different individuals. Occasionally adventitious eruptions have appeared in other parts of the body, which have been ascribed to absorption of antimony into the system.[1] But I believe with Rayer,[2] that they arise from the inadvertent application of the ointment to these parts. This ointment is used as a counter-irritant in various chronic maladies: thus it is applied to the chest in pulmonary affections, and to the joints in chronic diseases (whether rheumatic or otherwise). It should only be applied to sound portions of the skin, and, therefore, leech-bites, the scarifications from cupping, wounds, &c. are to be carefully avoided; for severe inflammation, and even gangrenous ulceration, may be produced by not attending to this caution. I have before mentioned that in a very few cases severe and even fatal constitutional disorder has appeared to have resulted from the use of antimonial ointment.

ORDER XXII. BISMUTH AND ITS COMPOUNDS.

108. BISMUTHUM.—BISMUTH.

Symbol Bi. *Equivalent Weight* 213.

HISTORY.—This metal is first mentioned by Agricola, in 1529. It has been termed *marcasita, tectum argenti*, or, by the Germans, *wismuth*. "The old miners call it wismuth," says Matthesius, "because it blooms like a beautiful meadow (*wiesematte*), on which variegated flowers of all kinds are blooming."[3]

NATURAL HISTORY.—Bismuth occurs only in the mineral kingdom. It is found in Cornwall, Saxony, Bohemia, &c. It is met with in the metallic state nearly pure (*native bismuth*), and in combination with sulphur and with oxygen.

PREPARATION.—It is chiefly obtained from native bismuth by melting the metal out of its gangue.

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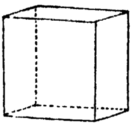
[1] *Gaz. Méd.* 1832, p. 842.

[2] *Treatise on Diseases of the Skin*, by Dr. Willis, p. 540.

[3] Schwartze, *Pharm. Tabellen.*

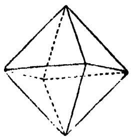
PROPERTIES.—It is a reddish-white metal, without taste or smell, composed of brilliant broad plates, and readily crystallizable in cubes or regular octohedrons (figs. 132 and 133). It belongs, therefore, to the regular system (see *ante*, p. 138). The sp. gr. of purified bismuth is, according to Karsten, 9·6542; that of commercial bismuth, according to Herapath, 9·833. It is moderately hard, brittle, pulverizable, fusible at 476° F. When strongly heated in the air it takes fire, and burns with a faint blue flame, emitting a yellow smoke (BiO^3). In close vessels it may be volatilized.

FIG. 132.



Cube.

FIG. 133.



Octohedron.

Characteristics.—It is distinguished by its brittleness, its ready fusibility, its solubility in nitric acid, and by the characters of its nitric solution: the ternitrate, $BiO^3,3NO^5,9HO$, when treated with water, yields a white precipitate, BiO^3,NO^5, HO; and when mixed with sulphuretted hydrogen, HS, or hydrosulphuret of ammonia, $NH^3,2HS$, a black precipitate, BiS^3.

PURITY.—Copper may be detected in bismuth by precipitating the nitric solution with ammonia: the supernatant liquor is blue if copper be present.

It is dissolved by diluted nitric acid; when subnitrate of bismuth is precipitated from this solution by ammonia, the liquor is free from colour. Its specific gravity is 9·8.—*Ph. Lond.*

Its powder is entirely soluble in nitric acid with the aid of heat; and the solution is colourless, or nearly so, and deposits a white powder when much diluted with cold water. —*Ph. Ed.*

PHYSIOLOGICAL EFFECTS AND USES.—In the metallic state bismuth is inert. Its only use in pharmacy is for the preparation of the nitrate.

109. BISMUTHI NITRAS.—NITRATE OF BISMUTH.

Formula BiO^3,NO^5,HO. *Equivalent Weight* 300.

HISTORY.—This compound was first prepared by Lemery. It has had various appellations, such as *pearl white, magistery of bismuth* (also a name for submuriate of bismuth), *spanish white, subnitrate, tetarto-nitrate,* or *trisnitrate of bismuth* (*bismuthi subnitras, tetarto-nitras,* vel *trisnitras*), or *white bismuth* (*bismuthum album*).

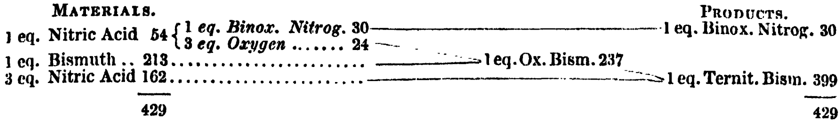
PREPARATION.—All the British Colleges give directions for the preparation of this salt.

The *London College* orders of Bismuth, ℥j.; Nitric Acid, f℥iss.; Distilled Water, Oiij. Mix a fluidounce of the water with the Nitric Acid, and dissolve the Bismuth in them; then pour off the solution. To this add the rest of the water, and set by that the powder may subside. Afterwards, the supernatant liquor being poured off, wash the Trisnitrate of Bismuth with distilled water, and dry it with a gentle heat.

The process of the *Edinburgh College* is essentially similar. The precipitate [the Trisnitrate] is directed to be collected on a calico filter, washed quickly with distilled water, and dried in a dark place.

The *Dublin College* directs it to be prepared with Bismuth reduced to powder, *seven parts;* Diluted Nitric Acid, *twenty parts;* Distilled Water, *one hundred parts.*

In the first part of this process we obtain a ternitrate of bismuth by the reaction of an equivalent of bismuth on four equivalents of nitric acid. One equivalent of binoxide of nitrogen is evolved, and an equivalent of ternitrate of bismuth formed. $Bi + 4NO^5 = BiO^3,3NO^5 + NO^2$.



Water decomposes the ternitrate of bismuth, and causes the precipitation of the nitrate (also called subnitrate, or trisnitrate), leaving a supernitrate in solution. $4(BiO^3,3NO^5) + HO = 3(BiO^3,NO^5,HO) + BiO^39NO^5$.

PROPERTIES.—It is a dull white, inodorous, tasteless pulveriform substance, which, when examined by a magnifier, is found to consist of very fine silky acicular crystals. It is nearly insoluble in water, but is readily dissolved by nitric acid. By exposure to light it becomes greyish.

Characteristics.—Hydrosulphuric acid, or the hydrosulphates, blacken it, by forming the tersulphuret of bismuth (BiS^3). It dissolves in nitric acid without effervescence. Heated on charcoal by the blowpipe flame it gives out nitrous acid (or its elements), and yields the yellow oxide of bismuth (BiO^3); and, by a continuance of the heat, the oxide is reduced, globules of metallic bismuth being obtained, which may be readily distinguished from globules of lead by their brittleness; for, when struck sharply by a hammer on an anvil, they fly to pieces: from antimony they are distinguished by their solubility in nitric acid.

COMPOSITION.—Nitrate of bismuth has the following composition:—

	At.	*Eq.Wt.*	*P.Ct.*	*Herberger.*	*Duflos.*	*Grouvelle.*	*Phillips.*[1]	*Menigaud.* (Dried at 212°.)
Teroxide of Bismuth	1	237	79	79·70	80·00	81·37	81·92	85·33
Nitric Acid	1	54	18	14·44	13·58	13·97	18·36	14·67
Water	1	9	3	5·86	6·42	4·66	0·00	0.00
Nitrate of Bismuth	1	300	100	100·00	100·00	100·00	100.28	100·00

PURITY.—Its freedom from any carbonate (as of lead) is known by its solution in nitric acid without effervescence. Diluted sulphuric acid added to the solution throws down a white precipitate, if lead be present.

> It is soluble in nitric acid without effervescence. Diluted sulphuric acid being added to the solution, nothing is thrown down.—*Ph. Lond.*
>
> It forms a colourless solution with nitric acid and without effervescence: not subject to adulteration.—*Ph. Ed.*

The microscope will distinguish the *hydrated oxide of bismuth,* (obtained by adding an alkali to the nitric solution of bismuth): the latter is amorphous, whereas nitrate of bismuth is crystalline.

PHYSIOLOGICAL EFFECTS. *a. On Animals.*—It acts as a local irritant and caustic poison. Moreover it appears to exercise a specific influence over the lungs and nervous system.[2]

β. On Man.—In *small doses* it acts locally as an astringent, diminishing secretion. On account of the frequent relief given by it in painful affections of the stomach, it is supposed to act on the nerves of this viscus as a sedative. It has also been denominated tonic and antispasmodic. Vogt[3] says, that when used as a cosmetic, it has produced a spasmodic trembling of the face, ending in paralysis.

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[1] *Phil. Mag.* Dec. 1830, p. 409.

[2] Orfila, *Toxicol. Gén.*

[3] *Pharmakodynamik*, i. 288, 2te Aufl.

Large medicinal doses disorder the digestive organs, occasioning pain, vomiting, purging, &c.; and sometimes affecting the nervous system, and producing giddiness, insensibility, cramps of the extremities, &c.

The following is the only reported case of poisoning with it. A man took two drachms by mistake, and died therefrom on the ninth day. In addition to the usual symptoms of gastro-enteritis, there was a disordered condition of the nervous system, indicated by cramps of the hands and feet, disordered vision, and delirium. It is deserving also of remark, that there were difficulty of breathing, and salivation. Post-mortem examination showed inflammation throughout the alimentary canal; the spinal vessels were gorged with blood, particularly towards the cauda equina; there was fluid in the cerebral ventricles; and the inner surface of both ventricles of the heart was very red. (Christison.)

An out-patient under my care at the London Hospital, took thrice daily, for a stomach affection, ℈j. of nitrate of bismuth, with a mixture containing hydrocyanic acid, for more than two months, without any inconvenience whatever: on the contrary, she declared she was greatly benefitted by its use.

Use.—It has been principally employed in those chronic affections of the stomach which are unaccompanied by any organic disease, but which apparently depend on some disordered condition of the nerves of this viscus; and hence the efficacy of the remedy is referred to its supposed action on these parts. It has been particularly used and recommended to relieve gastrodynia and cramp of the stomach, to allay sickness and vomiting, and as a remedy for pyrosis or waterbrash. In the latter disease I give it in the form of a powder, in doses of j. thrice daily, in conjunction with hydrocyanic acid mixture, and the patient rarely fails to obtain marked benefit from its use. Dr. Theophilus Thomson[1] recommends it in doses of five grains, usually combined with three of gum arabic and two of magnesia, given every four or six hours, in the diarrhœa accompanying phthisis. He thinks that, both in efficacy and safety, it surpasses our most approved remedies for that complaint.

It has also been administered in intermittent fever, in spasmodic asthma, &c. Hahnemann has recommended a portion to be introduced into a hollow tooth, to allay tooth-ache. I have used it, with advantage, in the form of ointment, applied to the septum nasi, in ulceration of this part, and as a local remedy in chronic skin diseases.

Administration.—The usual dose of this remedy is from five grains to a scruple. I seldom commence with less than a scruple, and have repeatedly exhibited half a drachm without the least inconvenience. It may be administered in the form of powder, linctus, or pill. The *ointment* which I have above referred to was composed of one drachm of the nitrate, and half an ounce of spermaceti ointment.

Antidotes.—No chemical antidote is known. Albuminous and other emollient drinks, as milk, should be administered, and the poison evacuated from the stomach as speedily as possible. The antiphlogistic plan is to be adopted, to obviate inflammation.

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[1] *Medico-Chirurgical Transactions*, 2d ser. vol. xiii. p. 305, 1848.

ORDER XXIII. ZINC AND ITS COMPOUNDS.

110. ZINCUM.—ZINC.

Symbol Zn. *Equivalent Weight* 32·5.

HISTORY.—Although the ancients were acquainted with the method of converting copper into brass by means of an ore of zinc, yet we have no positive evidence that they knew metallic zinc, one of the constituents of this alloy. Perhaps the *false silver*, or ψευδάργυρος of Strabo, may have been zinc, which is said to have been known from time immemorial in China and India. Albertus Magnus, who died in 1280, is the first writer who expressly mentions this metal.[1]

It has had various appellations, such as *contrefeyn*, *golden marcasite*, *Indian tin* (*stannum Indicum*), *spiaulter*, *speltre* or *spelter* (*speltrum*).

NATURAL HISTORY.—It occurs only in the mineral kingdom. It is found in the form of oxide (*red zinc*), of sulphuret (*blende* or *black jack*), of carbonate (*calamine*), of sulphate (*white vitriol*), of silicate (*electric calamine*), and aluminate (*automalite* or *gahnite*).

PREPARATION.—Zinc is usually procured from the native sulphuret or carbonate of that metal. It may also be obtained from the silicate.

The picked ore, being broken into small pieces, is submitted to a dull red heat in a reverberatory furnace. By this process the sulphur of the sulphuret is transformed into sulphurous acid, which escapes, and the zinc is oxidized; while the carbonate loses carbonic acid and water. The resulting oxide is then mixed with some carbonaceous substance (small coal or charcoal), and submitted to heat, by which the metal is reduced and vaporized. Sometimes the reduction is effected in a covered earthen jar or crucible, the bottom of which is perforated by an iron tube, which terminates over a vessel of water situated in an apartment below the furnace. The gaseous products and zinc escape by this tube; and the latter is condensed in the water. This is called *distillatio per decensum*. In Silesia, however, *distillatio per ascensum* is employed.[2]

The Bristol and Birmingham zinc works derive their chief supply of ores from the Mendip Hills and Flintshire; and Sheffield, from Alston Moor. Zinc is also imported in ingots and plates from Silesia, by way of Hamburg, Antwerp, Dantzic, &c.

PROPERTIES.—It is a bluish-white metal, of considerable lustre. It crystallizes in four-sided prisms and needles; its texture is lamellated and crystalline. Its sp. gr. is from 6·8 to 7·2. At common temperature it is tough; from 212° to 300° it is ductile and malleable, and may be readily rolled into thin leaves (*sheet zinc*); at 400° it is so brittle that it may be reduced to powder. It readily fuses, and, at a white heat, may be volatilized.

Characteristics.—It is soluble in dilute sulphuric acid, with the evolution of hydrogen gas. Ferrocyanide of potassium forms, in this solution, a gelatinous white precipitate (*ferrocyanide of zinc*, Zn^2, $FeCy^3$): if iron be present the precipitate is bluish-white. If the liquid be neutral, hydrosulphuret of ammonia (NH^3, $2HS$) occasions a precipitate of sulphuret of zinc, (ZnS), which is white if the solution be pure, but more or less coloured if iron be present, owing to the admixture of sulphuret of iron (FeS). Alkalies throw down a white precipitate (ZnO, HO). Carbonate of potash occasions a precipitate of the basic carbonate of zinc, $3(ZnO, HO) + 2(ZnO, CO^2)$.

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[1] Beckmann, in his *History of Inventions and Discoveries*, vol. iii. p. 71, has given a good account of the history of zinc.

[2] Dumas, *Traité de Chimie*, t. iv. p. 82; Ure, *Dict. of Arts and Manufactures*; also *Supplement*.

PURITY.—Commercial zinc is never pure. The following are analyses of it (L. Gmelin):—

	Austrian Zinc, analysed by Wittstein.			*Commercial Zinc, by Jacquelain.*
Zinc	96·27	99.05	98·76	99·170
Lead	3·33	0·27	0·91	0·685
Cadmium	0·30	0·23	0·16	0·000
Iron	0·10	trace	0·17	0·142
Carbon	0·00	0·00	0·00	0·003
	100·00	99·55	100·00	100·000

When commercial zinc is immersed in dilute sulphuric acid, the zinc, and any iron which may be present, dissolve, leaving a black pulverulent substance, which, according to Wittstein, consists of sulphuret of lead and carbon; but, according to Vogel, it is composed of carbon, sulphur, lead, and iron.

Almost entirely dissolved by diluted sulphuric acid. The solution is free from colour. Its other properties as above [see *Zinci sulphas*]. The specific gravity is 6·86.—*Ph. Lond.*

It dissolves in a great measure in diluted sulphuric acid, leaving only a scanty grayish-black residuum: this solution presents the characters just given [see *Zinci sulphas*] for the solution of sulphate of zinc.—*Ph. Ed.*

The ready solubility of commercial zinc in dilute sulphuric acid depends greatly on its impurity; for absolutely pure zinc is comparatively feebly acted on by this dilute acid.

To prevent what is termed the *local action* of sulphuric acid on the zinc, arising from the impurity of this metal, the plates of zinc employed in Daniell's, Grove's, and Smee's voltaic batteries are amalgamated.

PHYSIOLOGICAL EFFECTS.—In the *metallic* state zinc is inert. The *compounds of zinc* are somewhat analogous in their action on the system to those of copper, silver, and bismuth, but are much less energetic. They act topically, according to their degree of concentration, as desiccants, astringents, irritants, and caustics (see *ante*, pp. 157 and 158). Taken internally, they excite, more or less readily, nausea and vomiting; and in large doses operate as irritant and caustic poisons. They exercise a specific influence over the nervous system, though this is much less obvious than in the preparations of the other metals just referred to. The stupor and inactivity, mentioned by Orfila[1] as being produced by the sulphate, are evidence of the affection of the nervous system. The antispasmodic power evinced by zinc, in certain diseases, can only be explained by referring it to the action of this metal on the nervous centres (see *ante*, pp. 185 and 213).

USES.—As *topical* agents we employ the compounds of zinc as caustics, astringents, and desiccants. Thus the chloride is used as a caustic; the sulphate and acetate as astringents; and the oxide and carbonate as desiccants.

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[1] *Toxicol. Générale.*

Internally, the compounds of zinc are administered in large doses to excite vomiting; in smaller doses as tonics and antispasmodics in intermittent diseases and chronic affections of the nervous system.

The chloride is used as an antiseptic.

111. ZINCI OXYDUM.—OXIDE OF ZINC.

Formula ZnO. *Equivalent Weight* 40·5.

HISTORY.—The oxide was first prepared by Hellot in 1735. When obtained by burning the metal in the air it has received various names, some of them of a fantastic nature; as *nihil album*, *philosopher's wool* or *lana philosophica*, *pompholyx*, and *flowers* or *calx of zinc* (*flores* seu *calx zinci*).

NATURAL HISTORY.—Oxide of zinc is found in America, mixed or combined with the sesquioxide of manganese, and constituting the *red oxide of zinc* of the mineralogist. It is also found in various localities, in combination with carbonic, sulphuric, or silicic acid.

PREPARATION.—All the British Colleges give directions for the preparation of this compound.

The *London College* orders of Sulphate of Zinc, lbj.; Sesquicarbonate of Ammonia, ℥viss.; Distilled Water, *Cong.* iij. Dissolve the Sulphate of Zinc and Sesquicarbonate of Ammonia separately, in twelve pints of the distilled water, and strain; then mix. Wash what is precipitated frequently with water; and, lastly, burn it for two hours in a strong fire.

The *Edinburgh College* employs of Sulphate of Zinc, ℥xij.; Carbonate of Ammonia, ℥vj. The process is otherwise the same as that of the London College.

By the mutual reaction of sulphate of zinc and sesquicarbonate of ammonia, sulphate of ammonia is formed in solution, and the basic carbonate of zinc $3(ZnO,HO)+2(ZnO,CO^2)$ precipitated. By the subsequent ignition the carbonic acid and water are expelled.

The *Dublin College* directs Oxide of Zinc to be prepared as follows:—Take of Zinc, broken into small fragments, any required quantity. Let portions of the metal be thrown at separate intervals of time into a crucible heated to whiteness and of sufficient depth; its mouth inclining somewhat towards the door of the furnace; and after the injection of each piece of zinc, let another crucible be inverted over that which receives the metal, but loosely, that the air may not be excluded: let the sublimed light powder and the whitest part of it be preserved for use.

In this process the metal attracts oxygen from the air, and is thereby converted into oxide of zinc.

A manufacturing chemist, who prepares oxide of zinc (so called), informs me that he obtains it from a solution of chloride of zinc, which he procures from the workers of palladium. This liquid is boiled with small pieces of zinc and some caustic soda, to get rid of the iron; and to the clear liquor is then added a solution of carbonate of soda (soda ash), by which the white basic carbonate of zinc is precipitated. This is washed, dried, and sold as oxide of zinc.

PROPERTIES.—The form of the crystallized native oxide of zinc (containing the oxides of iron and manganese) is a right rhombic prism.

The artificial oxide of the Pharmacopœia is a white, or, when ignited, yellowish-white, tasteless, odourless powder. It is fusible, forming a yellow glass, and at a white heat is volatilized. When heated with charcoal it is readily reduced. It is insoluble in water, but readily dissolves in most acids and in alkalies. It forms two classes of salts: one (the *zincic salts*), in which it is the base; a second, (*zincates*) in which it acts the part of an acid.

Characteristics.—It dissolves in dilute sulphuric acid. The characteristics of the solution have been already detailed (see *ante*, p. 709).

COMPOSITION.—Oxide of zinc has the following composition:—

	Atoms.	*Eq. Wt.*	*Per Cent.*	*Proust.*	*Berzelius.*
Zinc	1	32·5	80·25	80	80·1
Oxygen	1	8	19·75	20	19·9
Oxide of Zinc	1	40·5	100·00	100	100·0

PURITY.—Pure oxide of zinc is completely and readily soluble in diluted sulphuric, nitric, or hydrochloric acid, without effervescence. The substance met with in the shops under the name of oxide of zinc is in reality a carbonāte of this metal, and, therefore, effervesces on the addition of an acid. The solution obtained by dissolving the oxide in any of the above acids yields a precipitate, on the addition of caustic ammonia or potash, which should be completely soluble in an excess of the precipitant.

The oxide of zinc of the shops sometimes yields traces of sulphuric acid when its solution in nitric acid is tested with a salt of baryta.

Oxide of cadmium has been sometimes found in it, and was once mistaken for arsenious acid.[1] Iron and manganese are sometimes present in oxide of zinc, and communicate a yellow tinge to it. The oxide is,—

White: tasteless: entirely soluble in diluted nitric acid without effervescence: this solution is not affected by nitrate of baryta, but gives with ammonia a white precipitate entirely soluble in an excess of the test.—*Ph. Ed.*

PHYSIOLOGICAL EFFECTS. *α. On Animals.*—Orfila[2] gave from three to six drachms of it to small and weak dogs: they were attacked with vomitings, without suffering much.

β. On Man.—Applied to ulcerated or other secreting surfaces, it acts as a desiccant and astringent substance. On account of its insolubility, the absorption of it must be very slow. Taken into the stomach in large doses, it acts as a slight irritant, and provokes vomiting, and sometimes purging. It is said to have also caused occasional giddiness and temporary inebriation. In small doses it may be taken for a considerable period without causing any obvious effects. Sometimes, under its employment, certain affections of the nervous system (as epilepsy, chorea, &c.) subside; from which we infer that it exercises some specific influence over this system; and it is, therefore, termed tonic, antispasmodic, and sedative. But the nature of its influence is not very obvious. By long-continued use it acts as a slow poison, and produces *tabes sicca.* A gentleman, for the cure of epilepsy, took daily, at an average, twenty grains of oxide till he had consumed 3246 grains, which must have taken him about five months. At the end of this time he was found of a pale, earthy hue, wasted away, and almost idiotical: his tongue was thickly coated, the bowels were constipated, the inferior extremities cold and œdematous, the abdomen tumid, the superior extremities cold and shrivelled, and their skin dry, like parchment; the pulse was about sixty, thready, and scarcely perceptible. Under the use of purgatives, a light nutritive diet, with tonic and diuretic medicines, he rapidly recovered, but he remained subject to epileptic attacks.[1]

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[1] Thomson, *Hist. of Chem.* ii. 219.

[2] *Toxicol. Gén.*

USES.—*Internally* it has been commended in some spasmodic diseases, viz., epilepsy, chorea, hysteria, catalepsy, and hooping-cough; and in some painful affections, as neuralgia and gastrodynia. Though occasionally serviceable in some of these maladies, it has so frequently failed, that practitioners have ceased to place much confidence in it.

Externally, it is employed in the form of powder, or lotion, or ointment. As a *dusting powder* it is useful, by its mild, absorbent, and desiccant properties, and is applied to impetiginous, eczematous, and other chronic diseases of the skin, attended with profuse secretion. It is also used to allay or prevent excoriation in children and bedridden persons, and to remove chaps and cracks of the nipples. In painful ulcers, with copious discharge, it is not unfrequently beneficial by its desiccant and sedative properties. *Diffused through water* or a *mucilaginous solution* (in the proportion of two drachms of the oxide to six or eight ounces of liquid), it is occasionally useful in chronic ophthalmia, especially *ophthalmia tarsi,* and in eczema. Sommé[2] employed an injection, composed of half an ounce of oxide and two pints of water, in gonorrhœa and leucorrhœa, with success.

ADMINISTRATION.—Internally, it is administered in the form of pill or powder, in doses of from two or three grains gradually increased to eight, ten, or more.

1. **UNGUENTUM ZINCI,** L. E.; *Unguentum Zinci Oxydi,* D.; *Zinc Ointment.* (Oxide of Zinc, ℥j.; Lard, ℥vj. M. *L.*—The *Edinburgh College* substitutes Simple Liniment for Lard.—The *Dublin College* uses of Ointment of White Wax, lbj.; Oxide of Zinc, prepared in the same manner as chalk, ℥ij. M.)—This compound is employed as a mild drying ointment in porrigo, impetigo, and other skin diseases attended with profuse discharges, after extensive burns, blisters, sinapisms, &c.; to painful ulcers with excessive secretion, to the eye when affected with chronic inflammation, &c.

2. **ZINCI OXYDUM IMPURUM;** *Impure Oxide of Zinc.*—This substance is known in the shops under the name of *tutty,* (*tutia* seu *tuthia*), or *furnace cadmia* (*cadmia fornacum* seu *factitia*). It is found in the chimney of the furnace in which zinc ores are roasted, or in which zinciferous lead ores are smelted. When prepared by levigation and elutriation it is called *prepared tutty* (*oxydum zinci impurum præparatum; tutia præparata*). It is applied as a dusting powder, or as a cooling ointment (*unguentum oxydi zinci impuri*); composed of Simple Liniment or Lard, 5 parts; Tutty, 1 part; M.) to excoriated surfaces.

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[1] *Brit. and For. Med. Rev.* July 1838, p. 221.

[2] *Archiv. Gén. de Méd.* i. 486.

112. ZINCI CARBONAS.—CARBONATE OF ZINC.

Formula ZnO,CO^2. *Equivalent Weight* 62·5.

HISTORY.—The native carbonate of zinc (*zinci carbonas impura*) was perhaps known to the ancients, though they were unacquainted with its nature. The term *calamine* (*calamina*) is applied both to the native carbonate and native silicate of zinc: the latter is called, by way of distinction, *electric calamine.*

NATURAL HISTORY.—Native carbonate of zinc, or calamine, is found in great abundance in several parts of England (in the counties of Somerset, Derby, Durham, &c.), as well as in various parts of the continent of Europe (in Carinthia, Hungary, Silesia, &c.) It occurs crystallized or in compact or earthy masses. Its colour varies, being more or less grey, yellow, or brown. Its sp. gr. is 4·2 to 4·5.

PREPARATION.—Calamine (*calamina*), or the impure carbonate of zinc (*carbonas zinci impura*), is directed to be calcined, in order to make it pulverizable. But in this process water, and more or less of the carbonic acid, is expelled. It is then reduced to a very fine powder (usually in mills), and is afterwards submitted to the process of elutriation. By this means we obtain *prepared calamine* (*calamina præparata*, L. E.; *zinci carbonas impurum præparatum*, D.)

Native calamine varies so considerably in its colour, owing to the admixture of foreign bodies, that the *prepared calamine* obtained from it cannot be uniform in its appearance. It is owing, probably, to this, and the desire to obtain a preparation of uniform colour, &c., that a factitious article is usually substituted in the shops for the genuine article.

Genuine prepared calamine is a greyish, yellowish, pinkish, or brownish powder. If quite pure—that is, composed of carbonate of zinc only—it is completely soluble, with effervescence, in nitric, hydrochloric, or sulphuric acid. Some of the accidental impurities in it are insoluble in these acids.

The prepared calamine usually found in the shops is in the form of a heavy pinkish or flesh-coloured powder, or made up into little masses.

Characteristics.—The effervescence with the mineral acids shows calamine to be a carbonate. The presence of zinc in the solution is determined by the tests before mentioned for this metal (see *ante*, p. 709). The action of these tests, however, is more or less impeded by the presence of foreign matters in calamine.

COMPOSITION.—Carbonate of zinc has the following composition :—

				Smithson.		
	Atoms.	*Eq. Wt.*	*Per Cent.*	(Mendip Ore.)		(Derbyshire Ore.)
Oxide of Zinc	1	40·5	64·8	64·8	to	65·2
Carbonic Acid	1	22	35·2	35·2	to	34·8
Carbonate of Zinc	1	62·5	100·0	100·0	to	100·0

IMPURITIES.—The substance sold in the shops as prepared calamine frequently contains only traces of zinc. If hydrochloric acid be poured on it, effervescence (owing to the escape of carbonic and hydrosulphuric acids) takes place, and a portion is dissolved, but the greater part remains undissolved.

Mr. Brett[1] found from 78 to 87·5 per cent. of *sulphate of baryta.* The remainder of the powder consisted of *oxide of iron, carbonate of lime, lead* [*sulphuret of?*], and mere *traces of zinc.*

Recently, Mr. Moore[2] has submitted specimens of commercial calamine, obtained from respectable drug houses in London, to analysis in the laboratory of the Pharmaceutical Society. The results are subjoined :—

	1.	2.	3.	4.		5.		6.
Carbonate Lime	3·6	5·8	5·6	1·3	Carbonate Lime	3·0	Silica	28·8
Peroxide Iron .	5·2	2·8	3·2	1·4	Phosphate Iron .	2·8	Oxide Zinc......	58·6
Sulphate baryta	89·3	85·2	82·8	90·8	Peroxide Iron...	3·7	Carbonate Lime	2·8
Water	1·9	6 2	8·4	6·5	Sulphate Baryta	84·8	Phosphate Iron.	6·6
					Water [5·7 ?]...	3 7	Water..........	3·2
	100·0	100·0	100·0	100.0		100·0		100·0

The results of these analyses show that samples 1, 2, 3, and 4, were factitious articles. Sample 5 may happen to have been a native mineral, substituted accidentally or designedly for calamine. Sample 6 is a specimen of electric calamine (*silicate of zinc*) which occurs along with carbonate of zinc in the Derbyshire lead mines, and which is known by its gelatinizing on the addition of hydrochloric acid.

PHYSIOLOGICAL EFFECTS.—Pure carbonate of zinc is probably similar in its action to the oxide.

USES.—Calamine is employed as a dusting powder for children, and as a mild desiccant and astringent in excoriations, superficial ulceration, &c.

1. CALAMINA PRÆPARATA, L.; *Prepared Calamine; Zinci Carbonas impurum præparatum,* D.; *Lapis Calaminaris præparatus.* (Burn the Calamine, then bruise it. Afterwards let it be made into a very fine powder in the same manner as we have directed chalk to be prepared, *L.*—The directions of the *Dublin College* are essentially similar). Some remarks on the preparation have been previously offered. The *Edinburgh College* gives no directions for the preparation of calamine.

2. CERATUM CALAMINÆ, L. E.; *Calamine Cerate; Unguentum Calaminæ,* D.; *Turner's Cerate; Ceratum Epuloticum.* (Calamine; Wax, āā lbss.; Olive Oil, f℥xvj. Add the calamine to the melted wax and oil when they begin to thicken, *L.*—The *Edinburgh College* uses of prepared Calamine, *one part;* and Simple Cerate, *five parts.*—The *Dublin College* employs of prepared Calamine, lbj.; and Ointment of Yellow Wax, lbv. M.) It is an excellent desiccant and astringent application (when prepared with good calamine) to burns, scalds, excoriations, superficial ulcerations, &c.

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[1] *Lond. Med. Gaz.* xx. 72.

[2] *Pharmaceutical Journal,* vol. viii. p. 70, 1848.

113. ZINCI SULPHAS.—SULPHATE OF ZINC.

Formula ZnO,SO^3. *Equivalent Weight* 80·5.

HISTORY.—This salt is said by Schwartze[1] to have been known towards the end of the 13th, or at the commencement of the 14th century; but Beckmann affirms it was not known before the middle of the 16th century.[2] It has had various names; as *sal vitrioli, white vitriol, white copperas,* and *gilla Theophrasti.*

NATURAL HISTORY.—It occurs native at Rammelsberg, near Goslar, in the Hartz; at Holywell, in Flintshire; and other places.

PREPARATION.—It is readily prepared by dissolving zinc in diluted sulphuric acid.

The *London College* orders of Zinc, in small pieces, ℥v.; Diluted Sulphuric Acid, Oij. Pour gradually the diluted Sulphuric Acid upon the pieces of Zinc, and, the effervescence being finished, strain the liquor; then boil it down until a pellicle begins to form. Lastly, set it aside that crystals may be formed.

The *Edinburgh College* observes that this salt may be prepared either by dissolving fragments of zinc in diluted sulphuric acid till a neutral liquid be obtained, filtering the solution, and concentrating sufficiently for it to crystallize on cooling,—or by repeatedly dissolving and crystallizing the impure sulphate of zinc of commerce, until the product, when dissolved in water, does not yield a black precipitate with tincture of galls, and corresponds with the characters laid down for sulphate of zinc in the List of the Materia Medica (see p. 717).

The *Dublin College* orders of Zinc, in small fragments, *thirteen parts;* Sulphuric Acid, *twenty parts;* Water, *one hundred and twenty parts.*

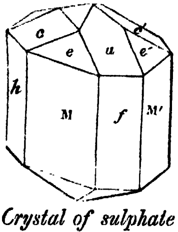
In this process one equivalent of water is decomposed; an equivalent of hydrogen escapes, while an equivalent of oxygen unites with one equivalent of zinc to form one equivalent of the oxide, which, with one equivalent of sulphuric acid, forms one equivalent of the sulphate. $Zn + HO,SO^3 = ZnO,SO^3 + H$. (See *ante,* p. 272).

The impurities in commercial zinc have been already stated (see *ante,* p. 710). If a piece of zinc be added to the impure solution of sulphate, and the liquid heated in contact with air, the iron is peroxidized and is deposited.

By roasting blende (*sulphuret of zinc*) in reverberatory furnaces, an impure sulphate is obtained, which is lixiviated, and the solution concentrated by evaporation, so that on cooling it forms a crystalline mass resembling lump sugar. This is distinguished among druggists by the name of *white vitriol,* (*vitriolum album*) a term which they confine to this commoner kind of sulphate. This impure salt contains iron, and usually copper and lead.

PROPERTIES.—Crystals of sulphate of zinc are right rhombic prisms (fig. 134), and belong to the right prismatic system (see *ante,* p. 141): they are transparent and colourless, and have a metallic astringent taste. They are soluble in $2\frac{28}{100}$ times their weight of cold water, and less than their own weight of boiling water. They are insoluble in alcohol. In dry and warm air they effloresce. When heated they undergo the watery fusion; and if the liquid be rapidly cooled, it congeals into a granular, crystalline, white mass: if the heat be continued the salt becomes anhydrous, and, at an intense heat, is decomposed, leaving a residue of zinc.

FIG. 134.



Crystal of sulphate of zinc.

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[1] *Pharm. Tabell.* 2te Ausg. 799.

[2] *History of Inventions,* iii. 85.

Characteristics.—That this salt is a sulphate, is proved by the action of chloride of barium on it; a white precipitate is produced, insoluble in nitric acid (see *ante*, p. 355). Acetate of lead also occasions a white precipitate. The presence of oxide of zinc in the solution is recognised by the tests already mentioned for this substance (see *ante*, p. 709).

COMPOSITION.—The crystallized sulphate has the following composition:—

	Atoms.	*Eq. Wt.*	*Per Cent.*	*Kühn.*	*Mitscherlich.*
Oxide of Zinc	1	40·5	28·22	28·02	55·24
Sulphuric Acid	1	40	27·88	27·70	
Water	7	63	43·90	44.28	44·76
Crystallized Sulphate of Zinc	1	143·5	100·00	100·00	100·00

PURITY.—Ammonia added to a solution of sulphate of zinc throws down a white precipitate soluble in excess of the precipitant. If any oxide of iron or magnesia be present it remains undissolved; while any oxide of copper would form an azure blue solution (*cuprate of ammonia*). Arsenic or cadmium may be detected by adding excess of sulphuric acid to the solution of the sulphate, and then passing a stream of hydrosulphuric acid through it: the arsenicum and cadmium are thrown down in the form of sulphurets. The impure sulphate called *white vitriol* occurs in irregular masses, here and there stained yellow with the iron.

Totally dissolved by water. What is thrown down by ammonia is white, and when the ammonia is added in excess it is again dissolved. On the addition of chloride of barium or acetate of lead they are decomposed.—*Ph. Lond.*

When a solution in six waters is boiled with a little nitric acid, and solution of ammonia is then added till the oxide of zinc first thrown down is all redissolved, no yellow precipitate remains, or a trace only, and the solution is colourless.—*Ph. Ed.*

PHYSIOLOGICAL EFFECTS.—In *small and repeated doses* it acts as an astringent on the alimentary canal, checks secretion, and promotes a constipated condition of the bowels. It exercises a specific influence over the nervous system, manifested by its power of removing certain spasmodic affections: hence it is reputed antispasmodic. To the same influence is to be referred its power of preventing the recurrence of intermittent maladies, from which it has principally derived its denomination of a tonic. Its astringent effect is not confined to the bowels, but is manifested in the pulmonary and urethral mucous membranes, the secretions from which it diminishes: hence the advantage of its use in catarrhal affections of these parts. It does not appear to possess any power of checking cutaneous exhalation.

In *full medicinal doses* it is a powerful but safe emetic; it excites speedy vomiting without giving rise to the same degree of distressing nausea occasioned by emetic tartar. Dr. Cullen[1] observes that "in order to render its effects certain, the dose must generally be large; and if this is not thrown out again immediately it is apt to continue a disagreeable nausea, or even a vomiting, longer than is necessary."

In *excessive doses* it acts as an irritant poison, causing vomiting, purging, coldness of the extremities, and fluttering pulse.

The *local action* of it is that of an astringent and desiccant, and in a concentrated form it is a powerful irritant and caustic. Its external use is said to have been found fatal in one case, by causing vomiting, purging, and convulsions.[1] Its causticity depends on its affinity for albumen and fibrin.

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[1] *Treat. of the Mat. Med.*

USES.—As an *emetic* it is almost exclusively employed in poisoning, especially by narcotics. In these cases it is the best evacuant we can administer, on account of its prompt action. As an *internal astringent* it is administered in chronic dysentery[2] and diarrhœa, in chronic bronchial affections attended with profuse secretion, and in gleet and leucorrhœa. In the latter cases it is usually associated with terebinthinate medicines, and is sometimes decidedly beneficial.[3] As an *antispasmodic* it has been employed with occasional success in epilepsy, chorea, hysteria, spasmodic asthma, and hooping-cough. I have little faith in its efficacy in any of these cases. It has recently been spoken favourably of by Dr. Babington[4] in the treatment of epilepsy. He has sometimes given as much as thirty-six grains three times a day. As a *tonic* it has been serviceable in agues, but it is far inferior to sulphate of quina or arsenious acid.

As a *topical astringent* sulphate of zinc is most extensively employed. We use its aqueous solution as a collyrium in chronic ophthalmia, as a wash for ulcers attended with profuse discharge, or with loose flabby granulations; as a gargle in ulcerations of the mouth, though I have found it for this purpose much inferior to a solution of sulphate of copper; as a lotion for chronic skin diseases; and as an injection in gleet and leucorrhœa.

ADMINISTRATION.—As an *emetic* the dose should be from ten to twenty grains; as a *tonic, antispasmodic*, or *expectorant*, from one to five grains.

For external use, solutions are made of various strengths. Half a grain of the sulphate to an ounce of water is the weakest. The strongest I ever knew employed consisted of a drachm of sulphate dissolved in an ounce of water: it was used with success as an injection in gleet. But solutions of this strength must be applied with great caution, as they are dangerous.

ANTIDOTES.—Promote the evacuation of the poison by demulcents. Afterwards allay hyperemesis by opium, blood-letting, and the usual antiphlogistic regimen. Vegetable astringents have been advised.

114. ZINCI CHLORIDUM.—CHLORIDE OF ZINC.

Formula $ZnCl$. *Equivalent Weight* 68.

HISTORY.—This compound, which has been long known to chemists, was first introduced into medicine by Papenguth,[5] and subsequently has been recommended by Professor Hancke, of Breslau,[6] and by Dr. Canquoin, of Paris.[7] It is termed *muriate, hydrochlorate*, or *butter of zinc*.

PREPARATION.—The easiest and cheapest method of obtaining it is by dissolving zinc, or its oxide, in hydrochloric acid, evaporating to dryness, and fusing in a glass vessel with a narrow mouth, as a Florence flask. In solution it is obtained as a secondary product in the preparation of some other metals, as of palladium (see *ante*, p. 711).

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[1] Christison, *op. cit.* p. 468.

[2] Impey, *Lond. Med. and Phys. Journ.* ix. 55, 1803.

[3] See a paper on this subject, by Mr. Graham, in the *Edinb. Med. and Surg. Journ.* vol. xxvi.

[4] *Guy's Hospital Reports*, No. xii. 1841.

[5] *Russ. Samml. f. Naturw. u. Heilk.* H. i. S. 79, quoted by Richter, *Ausf. Arzneim.* iv. 526.

[6] Rust's *Magazin*, 1826, Bd. xxii. S. 273.

[7] Dr. Alex. Ure, *Lond. Med. Gaz.* xvii. 391.

PROPERTIES.—It is a whitish-grey semi-transparent mass, having the softness of wax. It is soluble in water, alcohol, and ether. It is fusible; and, at a strong heat, may be sublimed and crystallized in needles. It is very deliquescent. It unites with both albumen and gelatine to form difficultly soluble compounds, and hence it occasions precipitates with liquids containing these principles in solution. A patent has been obtained by Sir William Burnett for the preservation of wood by a solution of the chloride of zinc.

Characteristics.—Dissolved in water it may be recognised to be a chloride by nitrate of silver (see *ante*, p. 369). That zinc is the base of the salt may be shewn by the tests already mentioned for the salts of this metal (p. 709).

COMPOSITION.—Its composition is as follows:—

	Atoms.	*Eq. Wt.*	*Per Cent.*	*J. Davy.*
Zinc	1	32·5	47·8	50
Chlorine	1	35·5	52·2	50
Chloride of Zinc	1	68·0	100·0	100

PHYSIOLOGICAL EFFECTS.—Its *local* action on living tissues is that of a caustic or escharotic, depending partly on its affinity for albumen and gelatine; so that when placed in contact with living parts into whose composition these organic compounds enter, the chloride exercising its affinity, destroys the life of the part, and unites with the albuminous and gelatinous matters present, and forms thus an eschar. Other chemical changes of a comparatively unimportant nature are also effected: thus, various salts found in the solids or liquids of the part may be decomposed. For example, when the chloride is applied to a cancerous sore, it decomposes the carbonate and hydrosulphuret of ammonia found in the secretion of the sore. The effects produced by the application of chloride of zinc are the following:—Soon after it has been applied a sensation of warmth is felt in the part, quickly followed by violent burning pain, which continues for seven or eight hours; that is, until the parts in contact with the chloride are dead. A white eschar is now observed, which usually separates in from eight to twelve days. Unless used in the neighbourhood of loose cellular tissue, there is rarely much swelling.

As a caustic, chloride of zinc is not inferior in power to chloride of antimony: nay, Vogt[1] says it appears to him to be more powerful and to penetrate deeper. It decomposes the organic tissues as quickly as the nitrate of silver, but excites more burning, and for a longer time, owing to its action extending to parts placed more deeply, for it is well known that the operation of the nitrate is confined to superficial parts. Both Vogt and Canquoin agree that chloride of zinc, besides corroding the parts with which it is in contact, exercises an influence over the vital actions of neighbouring parts. To this circumstance is owing, in great part, the efficacy of the chloride in various diseases in which it has been applied, and the healthy appearance of the sore after the separation of the eschar. There is no danger of any constitutional disorder arising from the absorption of the poison, as is the case with the arsenical and mercurial caustics.

Taken *internally*, in *large doses*, it acts as an irritant or caustic poison, and affects the nervous system. Thus it produces a burning sensation in the stomach, nausea, vomiting, anxiety, short breathing, small quick pulse, cold sweats, fainting, and convulsions. Taken in *very small doses*, no obvious effects are produced, except sometimes the amelioration of certain diseases. It is supposed in these cases to influence the nervous system.

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[1] *Pharmakodynamik*, i. 363, 2te Aufl.

Uses.—*Internally*, chloride of zinc has been given in small but gradually-increased doses in scrofula, epilepsy, chorea, and (in combination with hydrocyanic acid) in neuralgia of the face.

Commonly, however, it is employed *externally*: thus Papenguth used a dilute solution of it as a lotion in fistulous ulcers of a scrofulous nature. As a *caustic*, it has been applied by Professor Hancke and Dr. Canquoin to produce an issue, to destroy nævi materni, and as an application to parts affected with malignant diseases, such as fungus hæmatodes and cancer, or to other intractable forms of disease, such as old syphilitic or scrofulous ulcers. The benefit is supposed not to depend merely on the escharotic effect, but on the chloride inducing a new action in the surrounding parts.

Administration.—*Internally*, it may be given in doses of one or two grains. Hufeland recommends it to be taken dissolved in ether: his formula for the *æther zinci*, as it is called, is the following:—℞ Zinci Chlor. ʒss.; Alcoholis, ℥j.; Ætheris Sulph. ℥ij.: Post aliquot dies decanta. The dose of this solution is from four to eight drops taken twice daily.

Externally it has been used as a *lotion*, composed of two grains of the chloride and an ounce of water; or in the form of *paste*: this may be composed of one part of chloride of zinc, and from two to four parts of either wheaten flour, or plaster of Paris (sulphate of lime).

Sir W. Burnett's Disinfecting and Antiseptic Fluid is a solution of chloride of zinc. The solution sold for this purpose has a sp. gr. of 2·0, and contains 25 grains of zinc in every fluidrachm. In using it, one pint is mixed with five gallons of water.[1] Its action as an antiseptic and preservative depends on its combination with the dead animal tissues. Injected into the blood-vessels, it has been successfully employed to preserve anatomical subjects for dissection. It is said to have no injurious action on knives or other steel instruments, but the accuracy of this observation is doubtful. As a disinfectant and deodorizer, its action depends principally on its power of decomposing hydrosulphuret of ammonia. Its power of decomposing sulphuretted hydrogen is very limited. Unlike chloride of lime, it does not give out any disinfecting vapour.

115. ZINCI ACETAS.—ACETATE OF ZINC.

Formula $ZnO,C^4H^3O^3$; or $ZnO,\bar{A}$. *Equivalent Weight* 91·5.

History.—This salt was discovered by Glauber.

Preparation.—It may be procured by dissolving oxide of zinc in acetic acid, and crystallizing the saturated solution; $ZnO + \bar{A} = ZnO,A$. Or it may be readily obtained by double decomposition: 143½ grains of crystallized sulphate of zinc, dissolved in water, and mixed with 190 grains of crystallized acetate of lead in solution, will produce 152 grains of sulphate of lead, which, being insoluble, precipitates, while 91½ grains of the anhydrous acetate of zinc are left in solution. $ZnO,SO^3+PbO,\bar{A}=ZnO,\bar{A}+PbO,SO^3$. Or it may be procured by immersing a piece of zinc in a solution of acetate of lead, until the liquid forms a white precipitate with hydrosulphuric acid. In this process the lead is reduced to the metallic state (forming the *arbor saturni*, or *lead tree*), while the zinc replaces it in solution.

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[1] *Pharmaceutical Journal*, vol. vii. pp. 60 and 107, 1847.

PROPERTIES.—It usually crystallizes in rhomboidal plates, having a pearly or silky lustre closely resembling talc. The form of the crystals is the oblique rhombic prism. The salt is odourless, but has a bitter metallic taste. It dissolves readily in water, and is slightly efflorescent.

Characteristics.—When heated it fuses, and gives out an inflammable vapour, having the odour of acetic acid. When sulphuric acid is added to the salt, the vapour of acetic acid is evolved: this is easily recognized by its odour. These characters show it to be an acetate. That it is a zincic salt is proved by the tests before mentioned for a solution of this salt (pp. 709-10).

COMPOSITION.—Its composition in the crystallized state is, according to Dr. Thomson, $ZnO,\bar{A},7HO$. But according to Schindler it is $ZnO,\bar{A},3HO$.

PHYSIOLOGICAL EFFECTS.—Its effects are analogous to those of the sulphate of zinc. It local action is astringent. Taken internally, in small doses, it acts as a tonic and antispasmodic; large doses occasion vomiting and purging. Devaux and Dejaer[1] deny that it is a poison, even in large doses.

USES.—It is rarely administered *internally;* but is applicable as an emetic, tonic, and antispasmodic, in the same cases in which the oxide or sulphate of zinc is employed.

As a *topical* remedy, it is used, on account of its astringent qualities, in chronic ophthalmia, gleet, and leucorrhœa. In the latter stages of gonorrhœa I have found it far more successful than the sulphate. Its beneficial effects were first described by the late Dr. William Henry, of Manchester.[2] Sir A. Cooper[3] recommends, as the best injection which can be used in the third week of gonorrhœa, a mixture of six grains of sulphate of zinc and four ounces of liquor plumbi subacetatis dilutus. Of course double decomposition takes place, and the active ingredient is the acetate of zinc.

ADMINISTRATION.—When exhibited internally, as a tonic or antispasmodic, the dose is one or two grains gradually increased. As an emetic it is rarely administered: the dose is from ten grains to a scruple: its operation is very safe. As a lotion or injection, it is employed in the form of aqueous solution containing two or more grains of the salt to an ounce of water.

ZINCI ACETATIS TINCTURA, D.; *Tincture of Acetate of Zinc.* (Sulphate of Zinc, Acetate of Potash, aa. *one part.* Triturate them together, and add sixteen parts of Rectified Spirit; macerate for a week with occasional agitation, and filter through paper.)—Here we have double decomposition: sulphate of potash and acetate of zinc are formed. The first is precipitated, being insoluble in spirit; the second remains in solution. One drachm contains a quantity of acetate of zinc equal to about four grains of the crystallized acetate. When diluted with water it is used as a collyrium and injection.

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[1] Orfila, *Toxicol. Gén.*

[2] *Lond. Med. and Phys. Journ.* ix. 53, 1803.

[3] *Lancet*, iii. 199.

ORDER XXIV. CADMIUM AND ITS COMPOUNDS.

116. Cadmium.—Cadmium.

Symbol Cd. *Equivalent Weight* 64.

The metal *Cadmium*, also called *Klaprothium* and *Melinum*, was discovered in 1818, about the same time, both by Stromeyer and Hermann. It has received its name from *καδμεία*, or *καδμία*, an ancient name for calamine. The salts of cadmium yield with sulphuretted hydrogen, HS, as well as with hydrosulphuret of ammonia, $NH^3,2HS$, a yellow precipitate, CdS, resembling orpiment (see *ante*, p. 647). The only compound of cadmium which has been used in medicine is the sulphate. The general effects of the cadmium salts resemble those of the zinc salts.

117. Cadmii Sulphas.—Sulphate of Cadmium.

Formula CdO,SO^3. *Equivalent Weight* 104.

Cadmium Sulphuricum; Klaprothium Sulphuricum; Melinum Sulphuricum.—Obtained by dissolving carbonate of cadmium (CdO,CO^2) in dilute sulphuric acid, and evaporating the neutral liquid so that it may crystallize.—It may also be procured by dissolving 7 parts of cadmium in a mixture of 6½ parts of sulphuric acid, and 15 parts of water, with the addition of some nitric acid. $3Cd+NO^5+3SO^3+Aq=3(CdO,SO^3)+Aq+NO^2$. The solution is to be evaporated to dryness, the residuum redissolved in water, the solution filtered, and evaporated by a gentle heat so that crystals of the sulphate may be formed. These are right rectangular prisms, which resemble those of sulphate of zinc, and effloresce in the air. Their composition is $CdO,SO^3,4HO$. Sulphate of cadmium is readily soluble in water: its taste is astringent.

Sulphate of cadmium produces effects which resemble those of sulphate of zinc. Its action on animals has been investigated by both Rosenbaum[1] and Schubarth:[2] the former states that it is ten times as strong as sulphate of zinc; the latter found that in doses of 20 grs. it caused vomiting in dogs, but gave rise to no other injurious effect. Burdach[3] suffered a copious flow of saliva, and violent retching, vomiting, and pain, from half a grain of the sulphate. The topical effects of the sulphate are astringent and irritant.

Hitherto sulphate of cadmium has been almost exclusively used as a topical remedy, in ophthalmic surgery, in cases in which sulphate of zinc has been employed. In specks or opacities of the cornea, it has been successfully employed by Rosenbaum, Gräfe,[4] Guillié,[5] Ansiaux,[6] Kopp,[7] and others.

In chronic ophthalmia, it has been used by Gräfe and Giordano.[8] Lincke[9] has applied a solution of it as an injection in otorrhœa.

As a topical remedy, it has been employed in solution and in the form of ointment. A solution of from gr. ss. to gr. iv. of the sulphate in an ounce of water has been used as an application to the eye; and of from gr. iv. to gr. viij. in the like quantity of water in otorrhœa. As an eye ointment, gr. ij. of the sulphate to ℈iv. of fat have been employed.

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[1] *Diss. sistens experim. quædam de effect. cadmii in organism. animal. ejusque usu med.* Goett. 1819.

[2] Hufeland's *Journal*, Jan. 1821, S. 100.

[3] *Ibid.* Jan. 1827, S. 129.

[4] Gräfe u. Walther's *Journal*, Bd. i. St. 3, S. 554.

[5] *Bibl. Ophthalmologique.*

[6] *Clinique Chirurgicale*, Liège, éd. 2nde, 1829.

[7] *Denkwürdigkeiten*, Bd. i. S. 343.

[8] Dierbach, *Die neuesten Entdeck. in der Mat. Med.* Bd. i. S. 541, 1837.

[9] Aschenbrenner, *Die neueren Arzneimittel.* 1848.

ORDER XXV. TIN AND ITS COMPOUNDS.

118. STANNUM.—TIN.

Symbol Sn. *Equivalent Weight* 59.

HISTORY.—Tin has been known from the most remote periods of antiquity. It is mentioned by Moses[1] and by Homer.[2] The alchymists called it *Jove*, or *Jupiter*, ♃.

NATURAL HISTORY.—It is peculiar to the mineral kingdom. It occurs in two states; as an oxide, SnO^2 (the *tin stone* and *wood tin* of mineralogists), and as a sulphuret (*tin pyrites*, $2FeS,SnS^2+2Cu^2S,SnS^2$). It is found in both states in Cornwall, which has long been celebrated for its tin works. The Phœnicians, who were perhaps the first people who carried on commerce by sea, traded with England and Spain for tin at least 1000 years before Christ. Oxide of tin in very small quantities has been found in Saidschütz water, and in many meteoric stones (L. Gmelin).

PREPARATION.—In Cornwall, *stream tin* (a variety of *tin stone*) is smelted with charcoal or with culm in a reverberatory furnace. The metal thus procured is subsequently made hot, and then let fall from a height, or is struck with a hammer, by which it splits into a number of irregular prisms, somewhat like a basalt pillar. This is called *grain tin*: of this there are two kinds, the *best*, which is used for dyers,—and a second employed in the manufacture of tin plate, and which is called *tin-plate grain*. *Mine tin* (another variety of *tin stone*) is stamped, washed, roasted, afterwards smelted with Welsh culm and limestone, by which *block tin* is procured, the finest kind of which is called *refined tin*.[3]

Besides the two varieties of tin just described, other kinds are met with in commerce. *Malacca tin* occurs in quadrangular pyramids, with flattened bases. *Banca tin* is met with in wedge-shaped pieces.

PROPERTIES.—In its massive form it is a yellowish-white metal, having a peculiar odour when rubbed or handled, and crackling when bent. Its sp. gr. varies from 7·178 to 7·299. It melts at 442° F., and at a white heat is volatilized. It is malleable, and forms *sheet tin* and *tin foil* (*stannum foliatum*), but is sparingly ductile.

Characteristics.—Boiled in strong hydrochloric acid, we obtain a solution of protochloride of tin (SnCl), which has the following characters:—Potash added to it causes a white precipitate (SnO,HO) soluble in excess of the precipitant; hydrosulphuric acid produces a brown precipitate (SnS); and terchloride of gold, a dark purplish precipitate, called *the purple of Cassius*, and composed of $2(SnO,SnO^2)+AuO^2,SnO^2+6HO$. A small quantity of protochloride of tin added to a solution of corrosive sublimate, causes a white precipitate of calomel: a large quantity reduces the mercury to the metallic state. If protochloride of tin be heated with nitric acid, we obtain the bichloride ($SnCl^2$), which causes a yellowish precipitate (SnS^2) with hydrosulphuric acid.

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[1] *Numbers*, xxxi. 22.

[2] *Iliad*, xi. 25.

[3] Mr. John Taylor, *Ann. Phil.* iii. 449.

PURITY.—The London College gives the following characteristics of its purity:—

Boiled with hydrochloric acid, it is almost entirely dissolved. The solution is free from colour, but becomes purple on the addition of chloride of gold. What is precipitated by potash is white, and when added in excess it is redissolved. The specific gravity of tin is 7·29.—*Ph. Lond.*

PHYSIOLOGICAL EFFECTS.—In the mass, tin has no influence on the body, except that arising from its form and weight. Powdered tin is not known to produce any disorder in the functions of the body. It appears, however, that acid, fatty, saline, and even albuminous substances, may occasion colic and vomiting by having remained for some time in tin vessels.

Oxide of tin is poisonous, according to Orfila;[1] but Schubarth[2] found it inactive.

USES.—Tin foil is useful in pharmacy for covering the tops of pots containing pommades, electuaries, &c.; it is also employed for enveloping chocolate, &c.

Tin powder and tin filings are used as vermifuges.

STANNI PULVIS, E. D.; *Powder of Tin; Granulated Tin.*—This may be prepared in various ways.

The *Edinburgh College* gives the following directions for its preparation:—Melt tin in an iron vessel; pour it into an earthenware mortar heated a little above the melting point of the metal; triturate briskly as the metal cools, ceasing as soon as a considerable portion is pulverized; sift the product, and repeat the process with what remains in the sieve.

The *Dublin College* orders of the purest tin any required quantity. Liquefied by heat, let it be strongly agitated until it passes into a powder, which, when cold, is to be shaken through a sieve.

Tin may be reduced to powder by shaking it when melted in a wooden box, the inside of which has been rubbed with chalk.

When finely granulated, 100 grains are entirely converted into a white powder by three fluidrachms of nitric acid (*D.* 1380); and distilled water, boiled with this powder and filtered, is colourless, and precipitates but faintly, or not at all, with solution of sulphate of magnesia.—*Ph. Edinb.*

The sulphate of magnesia is employed to detect the presence of nitrate of lead in solution, with which it yields a white precipitate of sulphate of lead.

Powdered tin has been employed with great success by various practitioners as a vermifuge, particularly in tape-worm (see *ante*, pp. 155, 230, and 232). Dr. Alston[3] explains its operation on mechanical principles: he supposes that the powder of tin gets betwixt the worms and the inner coat of the alimentary canal, and causes them to quit their hold, so that purgatives easily carry them away with the fæces. It has, however, been asserted that water in which tin has been boiled is anthelmintic, at least so say Pitcairn and Pietsch;[4] wine which has been digested in a tin vessel is also stated to be noxious to worms. If these statements be true, the before-mentioned mechanical explanation is inadmissible. Some have therefore supposed that the efficacy must depend on the tin becoming oxidized in the alimentary canal; others have fancied that arsenic, which is frequently found in tin, is the active agent; while, lastly, some have imagined that the metal, by its action on the fluids of the canal, generated hydrogen, or hydrosulphuric acid, which destroyed these parasites. Considering that several compounds of tin operate as anthelmintics, we may fairly conclude that tin powder yields some compound of tin in the alimentary canal, which acts as a vermifuge. Dr. D. Monro, Fothergill, and Richter, have used powdered tin in epilepsy produced by worms, and, as it is stated, with advantage. It is commonly employed in doses of one or two drachms. Alston's mode of employing it as a vermifuge was the following :—The patient was well purged with senna, and on the following morning *one ounce* of tin powder was given in four ounces of treacle : on each of the two following days half this quantity was taken, and then the patient again purged. *Tin filings* (*stanni limatura* seu *rasura stanni*) have also been used in medicine.

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[1] *Toxicol. Gén.*

[2] Quoted by Dr. Christison, *Treatise on Poisons.*

[3] *Med. Essays*, v. 89, 92; also, *Lect. on Mat. Med.* i. 150.

[4] Quoted by Richter, *Ausf. Arzneim.* iv. 553.

119. Stanni Bisulphuretum.—Bisulphuret of Tin.

Formula SnS^2. *Equivalent Weight* 91.

Aurum Musivum, or *Mosaic Gold.* Obtained by subjecting to heat a mixture of tin, mercury, sal ammoniac, and sulphur. The mercury facilitates the fusion of the tin and its combination with sulphur ; the sal ammoniac keeps down the temperature, and thereby prevents the conversion of the bisulphuret into protosulphuret of tin.—It has a beautiful golden lustre, a flaky texture, and a greasy or soapy feel. In the arts it is used as a *bronze powder*, especially by the manufacturers of paper-hangings. In medicine it has been used as an anthelmintic for tænia ; in doses of from ʒij. to ʒiv., mixed with honey, as an electuary.

120. Stanni Chloridum.—Chloride of Tin.

Formula $SnCl$. *Equivalent Weight* 94·5.

Protochloride of Tin ; Protomuriate of Tin ; Stannum Muriaticum Oxydulatum ; Salt of Tin. Obtained by dissolving granulated tin in boiling hydrochloric acid, and evaporating the solution so that it may crystallize. The crystals (the *hydrated chloride of tin*, $SnCl, HO$) are colourless and transparent; by the aid of water they are decomposed into the hydrochlorate of the chloride, which remains in solution, and a white pulverulent oxichloride ($SnCl, SnO$), which precipitates : an excess of hydrochloric acid prevents this decomposition. The chemical characteristics of chloride of tin have been already stated (see *ante*, p. 723). Chloride of tin acts topically as an astringent, irritant, and caustic. After its absorption it acts, like the antimonials, powerfully on the skin. When taken as a poison, it causes convulsive movements of the muscles of the extremities and of the face, and sometimes paralysis. It has been used as a vermifuge against tape-worm; as an antispasmodic in epilepsy, chorea, and other convulsive diseases ; as a stimulant to paralysed muscles in paraplegia; as an antidote in poisoning by corrosive sublimate ; and as an external application in chronic cutaneous diseases. Internally, it is administered in doses of from $\frac{1}{16}$th of a grain to half a grain twice or thrice a day, taken either in spirit of hydrochloric ether or in the form of pills. Externally, it has been used in the form of aqueous solution, prepared by dissolving from $\frac{1}{8}$th of a grain to 1 grain in an ounce of distilled water. In case of poisoning by the chlorides of tin, milk and other albu substances should be administered (see *ante*, p. 161).

ORDER XXVI. LEAD AND ITS COMPOUNDS.

121. PLUMBUM.—LEAD.

Symbol Pb. *Equivalent Weight* 104.

HISTORY.—This metal was known in the most remote ages of antiquity. It is mentioned by Moses.[1] The Greeks called it μόλιβδος; the alchymists, *saturn*, ♄.

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[1] *Job*, xix. 23, 24; *Exodus*, xv. 10.

NATURAL HISTORY.—It is found both in the metallic state (*native lead?*) and mineralized. It is met with combined with sulphur (*galena*), with selenium, with chlorine (*horn lead*), with oxygen (*native minium*), and with oxygen and an acid, forming an oxy-salt (*carbonate, phosphate, sulphate, tungstate, molybdate, chromate, arseniate,* and *aluminate*).

PREPARATION.—It is usually extracted from galena (PbS), which is roasted in reverberatory furnaces, by which it loses the greater part of its sulphur as sulphurous acid, SO^2, and is converted into a mixture of lead, oxide of lead, sulphate of lead, and some undecomposed sulphuret of lead, and afterwards smelted with coal and lime; the first to abstract oxygen, the second to remove the sulphur. Oxide of lead readily decomposes sulphuret of lead under the influence of heat, and produces sulphurous acid and metallic lead. $PbS + 2PbO = 3Pb + SO^2$. Sulphuret of lead, and sulphate of lead also at a red heat, yield metallic lead and sulphurous acid. $PbS + PbO,SO^3 = 2Pb + 2SO^2$.

PROPERTIES.—It has a bluish-gray colour and considerable brilliancy. It may be crystallized, by cooling, in four-sided pyramids. It is malleable, but not ductile. Its sp. gr. 11·35. It has a peculiar odour when handled. It fuses at 612° F., and at a red heat boils and evaporates. By exposure to the air it attracts, first oxygen, and then carbonic acid.

Pure distilled water has no action on lead,[1] provided the gases (as air and carbonic acid) be excluded; but if these be admitted, a thin crust of basic carbonate of lead is soon formed.[2] It is remarkable that the presence of most neutral salts, especially carbonates and sulphates, impairs the corrosive action of air and water, and, therefore, exerts a protective influence. The chlorides (muriates) are the least protective. Hence, therefore, we can easily understand why leaden cisterns and pipes do not more frequently give a metallic impregnation to water; and why very pure well-water or rain-water is more apt than common well-water to become impregnated with lead (see *ante*, p. 283).

The water of Ascot Heath is deficient in those salts which exert a protective influence on water, and, therefore, readily acquires a plumbeous impregnation[3] from the pipes through which it passes. The dogs[4] of the Royal kennel suffered with saturnine paralysis (called *kennel lameness*) from this circumstance, and various persons also manifested symptoms of lead poisoning from the same cause.[5]

Characteristics.—If lead be dissolved in nitric acid, we may easily recognise its presence in the solution (PbO,NO^5) by the following tests:—Sulphuretted hydrogen and fresh prepared hydrosulphuret of ammonia[6] occasion a black precipitate (PbS); ammonia and potash cause a white precipitate (PbO, with some subnitrate); carbonate of potash and of soda produce a white precipitate (PbO,CO^2); sulphuric acid and the sulphates, a white precipitate (PbO,SO^3); ferrocyanide of potassium, a white precipitate ($Pb^2,FeCy^3$); chromate of potash, yellow (PbO,CrO^3); and iodide of potassium, yellow (PbI). A piece of zinc throws down metallic lead in an arborescent crystalline form.

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[1] For some observations on this subject, see Dr. Taylor's memoir in the *Guy's Hospital Rep.* vol. iii.

[2] Christison, *Transactions of the Royal Society of Edinburgh*, vol. xv. part ii. 1842.

[3] Squire, *Pharm. Journ.* vol. iv. p. 9, July 1844; Dr. Ryan, *Lond. Med. Gaz.* Aug. 1, 1845, p. 598.

[4] *Times*, Jan. 9, 1842; *Sunday Times*, March 26, 1843.

[5] Pearl, *Lond. Med. Gaz.* Aug. 1, 1845, p. 598.

[6] Hydrosulphuret of ammonia which has been exposed to the air for some time yields a red precipitate (*polysulphuret of lead?*) in a solution of lead (see *ante*, p. 647).—"If a solution of nitrate of lead be precipitated with hydrochloric acid, and the filtered solution treated with hydrosulphuric acid (HS), instead of the black sulphide usually formed by that reagent in solutions of lead, there is produced a red precipitate, which is chloro-sulphide ($3PbS,2PbCl$)." (J. E. Bowman, *Introduction to Practical Chemistry*, pp. 101 and 102, 1848.)

PHYSIOLOGICAL EFFECTS. **1. Of Metallic Lead.**—Metallic lead is probably inert. Three ounces and six drachms have been administered to a dog without any obvious effects.[1] As, however, it readily becomes oxidated, it occasionally acquires activity. Paulini[2] says colic was produced by a leaden bullet having been swallowed. Proust[3] states that an alloy of tin and lead is less easily oxidated than pure lead.

2. Of the Preparation of Lead. α. *On Vegetables.*—See *Plumbi Acetas.*

β. *On Animals.*—The effects on animals are similar to those on man.

γ. *On Man.*—With few exceptions all the compounds of lead are poisonous. Orfila[4] gave an ounce of the *sulphuret* to dogs with impunity; and four ounces have been given to horses without ill effects. Mr. Braid[5] says that the workmen who dig and pulverise the sulphuret at the Lead Hills in Lanarkshire never have lead colic until they work at the smelting furnaces. The *sulphate* has also been said to be inert; but there is doubt about this (see pp. 185 and 731). All the other preparations of lead are more or less active.

The general effects of lead have been described in a previous part of this work (see *ante*, pp. 184-188). The preparations of this metal act chemically on the animal tissues and fluids. They are usually described as possessing astringent and sedative qualities. By long-continued use they impoverish the blood (see *ante*, p. 186), and give rise to paralysis.

1. *General or primary effects of lead.*—These constitute what Tanquerel des Planches calls *primitive saturnine intoxication*. Under this head are included—1st, the sedative and astringent effects of lead; 2ndly, the leaden discolouration of the gums, the buccal mucous membrane, and the teeth; 3rdly, the lead taste and breath; 4thly, lead jaundice; 5thly, lead emaciation (*tabes saturnina* vel *sicca*). These effects have been before noticed (see *ante*, p. 187). To the account already given it will only be necessary to add a few observations on the primary effects of small and large doses of lead.

In *small doses* the preparations of lead act on the alimentary canal as astringents, checking secretion and causing constipation. After absorption, the constitutional effects of lead are observed: the arteries become reduced in size and activity, for the pulse becomes smaller and frequently slower also, the temperature of the body is diminished, and sanguineous discharges, whether natural or artificial, are frequently checked, or even completely stopped. This constringing and sedative effect seems extended to the secreting and exhaling vessels, the discharges from the mucous membranes, the exhalation from the skin, and the urine, being diminished in quantity. Thus we observe dryness of the mouth and throat, thirst, greater solidity of the alvine evacuations, diminution of the bronchial secretion and of cutaneous exhalation. Besides the leaden discolouration of the gums, mucous membrane of the mouth, and teeth, caused by lead, and which have been before described (see *ante*, p. 187), other allied effects have been described; viz. salivation,[6] turgidity of the gums,[1] and a bluish colour of the saliva (Christison). "I do not wish to assert," observes Dr. Burton, "that salivation and turgidity of the gums are never produced by the internal operation of lead, but I venture to affirm they are rare occurrences, and not characteristic of its influence."

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[1] *Journ. de Méd. de Leroux*, xxiii. 318.

[2] *Miscell. Nat. Cur. Dec.* ii. Ann. vi. App. p. 7, quoted by Voigtels, *Arzneimittellehre.*

[3] *Ann. de Chim.* lvii. 84.

[4] *Toxicol. Gén.*

[5] Christison. *op. cit.* 518.

[6] Dr. Warren, *Medical Transactions*, vol. ii. p. 87.

In *very large doses* some of the plumbeous preparations (the acetate, for example) act as irritant and caustic poisons, giving rise to the usual symptoms indicative of gastro-enteritis.

2. *Special diseases caused by lead.*—These are colic, arthralgy, paralysis, and brain disease, or, as it has been termed, encephalopathy. These maladies are not of equally frequent occurrence. According to the observations of Tanquerel des Planches,[2] the proportions are as follows:—

Colic	1217 cases.
Arthralgy	755 "
Paralysis	127 "
Encephalopathy	72 "

These diseases may appear separately, or two or three of them may be combined in the same individual. According to my observation, colic is usually the first observed; but Tanquerel des Planches says that they are all equally liable to appear at the commencement or close of the disease.

a. *Lead or saturnine colic* is characterized by sharp, continuous abdominal pains, attended by exacerbations, diminishing, or, if increasing, but little, by pressure, accompanied with hardness and depression of the walls of the abdomen, obstinate constipation, vomiting or nausea, excretion of intestinal gas through the mouth, anorexy, dysury, slowness and hardness of the pulse, agitation, anxiety, an increase of the sensibility and perversion of the contractility and secretions of the diseased organs.[3]

De Haen and Mérat, on examining the bodies of patients who have died affected with lead colic, found a contracted condition of the colon. But Sir G. Baker, Andral,[4] Louis, and Copland,[5] have not, in some cases, found any alteration. Moreover, it would appear probable from Dr. Abercrombie's observations on ileus,[6] that the empty and collapsed portion of the intestine was not the seat of the colic, but another part found in a state of distension,—for the collapsed or contracted state is the natural condition of healthy intestine when empty, while the distended portion is, in ordinary cases of ileus, the primary seat of the disease—the distension arising from a paralytic condition of the muscular fibres, whereby it is unable to contract and propel its contents onward. Now this view of the case is the more probable, since the action of lead on the muscular fibres of the intestine is doubtless of the same kind as that on the fibres of the voluntary muscles. In conclusion, we may affirm with Tanquerel des Planches that there are no anatomical alterations perceptible to the senses which produce all the pathological phenomena of lead colic, and that the material alterations that may be found are only effects, and not causes, of the symptoms observed during life.

The writer just quoted considers lead colic to be neuralgia of the digestive and urinary organs, produced by the introduction and absorption of lead in a molecular state into the system.

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[1] Dr. A. Thomson, *Elem. of Mat. Med.* ii. p. 66; and Laidlaw, in the *Lond. Med. Rep.* N.S. vi. 292.

[2] *Traité des Maladies de Plomb.* Paris, 1839.

[3] Tanquerel des Planches, *Traité des Maladies de Plomb.* Paris, 1839; also, Dana, *Lead Diseases*, Lowell, 1848.

[4] *Path. Anat.* by Townsend and West, ii. 140.

[5] *Dict. Pract. Med.* i. 366.

[6] *On Diseases of the Abdominal Viscera.*

Lead colic is accompanied by the blue line on the gums above referred to, which, therefore, is an important aid in distinguishing this variety of colic from that which arises from other causes.

Dr. Anthony Todd Thomson[1] is of opinion that carbonate of lead is the only preparation of this metal that can produce colic; but though he has, I think clearly, shown that lead colic more frequently arises from the carbonate than from any other salt of lead, he has, in my opinion, failed in proving that no other preparation of lead *can* produce it. Indeed, if his opinion were true, it would constitute an exception to the general effects of the metallic preparations; for we do not find that the specific effects of arsenic, or of mercury, or of copper, or of antimony, are produced by one preparation only: so that, *à priori*, analogy is against the opinion. Furthermore, it is well known that the vapour of the oxide of lead taken into the lungs may produce colic, and that the ingestion of the nitrate, acetate, citrate, or tartrate of lead, is capable of exciting the same effect. Now Dr. Thomson explains these facts by assuming that the oxide of lead unites with carbonic acid in the lungs, and is thus converted into carbonate; and that the acetate, citrate, and tartrate, are decomposed in the alimentary canal, and converted into carbonates. But it appears to me to be much more simple and consistent with analogy to admit that these preparations are of themselves capable of producing colic, than to assume that they undergo the changes here supposed. Moreover, in some instances in which colic was produced, it is unlikely that these changes would have occurred, owing to the excess of acid taken with the salt of lead.

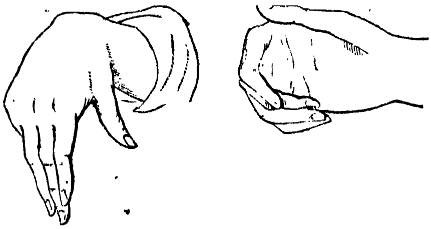
b. *Lead arthralgy*, called by Sauvages *metallic rheumatism*, is characterised by sharp pains in the limbs, unaccompanied by either redness or swelling, not precisely following the track of the nervous cords—constant, but becoming acute by paroxysms, diminished by pressure, increased by motion, and accompanied by cramps and hardness and tension of the painful parts.

Lead arthralgy is most readily distinguished from other kinds of arthralgy by the discolouration of the gums which characterises poisoning by lead.

The disease appears to be a purely nervous lesion. No anatomical changes have been recognised in the affected parts, though Devergie has detected lead in the muscles of a patient who suffered with it.

c. *Lead* or *saturnine paralysis* is characterised by a loss of voluntary motion, owing to the want of contractility of the muscular fibres of the affected parts. It may happen in both upper and lower extremities, though more frequently in the former; and it affects the extensor more than the flexor muscles, so that the hands are generally bent on the arms, which hang dangling by the side. Frequently pain is experienced in the paralysed part, and sometimes in the region of the spine also. On examining the bodies of persons who have died

FIG. 135. FIG. 136.



Wrist-drop and emaciated condition of the flexors of the thumb in the paralysis from lead. (M. Hall.)

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[1] *Lond. Med. Gaz.* v 538, and x. 680.

with this disease, no lesion has hitherto been discovered in the spinal marrow. The muscles of the affected limb are observed to be wasted and very pale, and have sometimes the appearance of a white fibrous tissue.

Paralysis of sensation is called *lead anæsthesy*. It may accompany the paralysis of motion, or may exist without it.

Lead paralysis may occur without colic, or it may come on while the patient is suffering with it, but in general it succeeds colic.

When recent, it is distinguished from other kinds of paralysis by the blue line on the gums before described.

d. *Disease of the brain caused by lead; Lead or saturnine encephalopathy.*—This malady is characterised by a lesion of one or more of the cerebral functions. There are four forms of it. In the first or *delirious* form, delirium, either tranquil or furious, is the leading feature of the disease. In the second or *comatose* form, coma, more or less profound, characterises it. In some cases it is accompanied with a slight delirium. In the third or *convulsive* form, convulsions are the principal character of the malady. They may be partial or general,—they may constitute epilepsy, or they may be epileptiform or cataleptiform; that is, they may resemble, though they do not exactly constitute, true epilepsy or catalepsy. Lastly, in the fourth form of encephalopathy we have the reunion of the delirious, comatose, and convulsive forms.

These functional lesions are not always accompanied by anatomical alterations in the conditions of the brain. Chemical analysis, however, has detected lead in the brain (see *ante*, p. 186).

MODUS OPERANDI.—Tiedemann and Gmelin[1] found lead in the blood of the splenic, mesenteric, and hepatic veins of dogs killed by the acetate; they also found it in the contents of the stomach and intestines, but neither in the chyle nor the urine. Wibmer[2] detected it in the liver, muscles, and spinal cord. More recently Orfila[3] has recognised lead in the liver, spleen, and urine of animals poisoned by a salt of this metal. (See also *ante*, pp. 102 and 186.)

The local or corrosive action of the soluble salts of lead depends on the affinity of these bodies for the organic constituents of the tissues (vide *plumbi acetas*).

The remote effects of lead probably depend on the local action of the absorbed metals on the parts whose functions are disordered. The detection of lead in the brain, spinal cord, and muscles of persons poisoned by a plumbeous salt, supports this view (see *ante*, p. 186). These parts have, therefore, become chemically altered.

Absorption of the plumbeous preparations may be effected by the digestive organs, by the respiratory organs, by the conjunctiva, and probably also by the skin. Tanquerel des Planches endeavours to prove the impossibility of absorption by the latter; but his arguments are not conclusive, and are opposed to ordinary experience. The poisonous effects of lead may arise from the introduction of the plumbeous particles into the stomach along with articles of food and drink; or into the air-passages, in the form of dust or vapour, along with the air; or from their application to the conjunctiva, skin, ulcers, &c. Hence the persons most liable to these effects are those whose occupations bring them in contact with this metal; for example, painters, plumbers, roasters and smelters of lead, the manufacturers of the plumbeous preparations, glass-blowers, potters, lapidaries, &c.

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[1] *Vers. über d. Wege, auf welchen Subst. aus d. Mag. ins Blut. gelang.*

[2] Christison's *Treatise on Poisons*, 3d edit. p. 509.

[3] Orfila, *Traité de Toxicologia*, 4me édit. tom. i. pp. 669 and 684, 1843.

Lead is eliminated from the system by the urine, by the skin, by the milk (see *ante*, p. 186), and probably by the bowels.

USES.—The general objects for which the preparations of lead are employed in medicine have been already pointed out (see *ante*, p. 188).

The nitrates and acetates of lead have been used as disinfectants (see *ante*, p. 162), and probably by the bowels.

During their administration, attention must be paid to the condition of the gums, the stomach, and the bowels, as we find traces of their injurious effects in these organs. Especial attention should be paid to the appearance of the blue-line on the gums. Constipation is a very frequent result of the medicinal employment of lead. Loss of appetite, indigestion, and griping pains, are also often noticed. The tendency to colic is diminished, according to Dr. A. T. Thomson, by conjoining acetic acid.

ANTIDOTES.—There are two classes of agents which lessen or destroy the poisonous effects of lead; these are sulphuretted hydrogen, and the soluble metallic sulphurets, on the one hand; and sulphuric acid and the soluble sulphates, on the other. The first render lead inert, by forming with the lead salts the black inert sulphuret of lead, PbS; the second do so by giving rise to the white insoluble sulphate of lead, PbO,SO^3. It may be doubted, however, whether this last mentioned compound be absolutely inert; for it is plausibly stated by Mialhe that under the influence of the alkaline chlorides (common salt, for example) contained in the animal fluids, the sulphate becomes partially or wholly converted into chloride of lead, $PbO,SO^3+NaCl=PbCl,+NaO,SO^3$, which being soluble is capable of becoming absorbed and of acting deleteriously on the system (see *ante*, p. 185). Moreover the alkaline acetates, as of ammonia, dissolve sulphate of lead. The soluble metallic sulphurets, on the other hand, cannot be extensively used as antidotes, as they are themselves energetic poisons; and, moreover, Rayer found that their internal use was not so successful as chemical reasoning had led him to expect.

The following are, I believe, the best antidotal means of counteracting lead poisoning:—

1. *Antidotal treatment of acute lead poisoning.*—Administer large quantities of diluents acidulated with sulphuric acid or holding in solution some soluble alkaline or earthy sulphate, as sulphate of soda, sulphate of magnesia, or alum.

Dr. Alfred Taylor recommends a mixture of sulphate of magnesia and vinegar to be administered in poisoning by white lead (carbonate of lead). The acetic acid of the vinegar dissolves the lead, which is immediately rendered insoluble by the sulphate of magnesia.

If vomiting have not already come on, the poison should be evacuated from the stomach by the means before recommended (see *ante*, p. 159).

2. *Antidotal treatment of chronic poisoning by lead.*—This method of treatment applies to the lead diseases before mentioned (see *ante*, pp. 188 and 728), as well as to all cases in which patients are suffering from the primary effects of lead (see *ante*, p. 727).

Immerse the patient in the sulphurated bath, prepared by dissolving sulphuret of potassium in warm water (see *ante*, p. 482). This immediately converts all the oxide, carbonate, or other salts of lead deposited on the skin, into the brown or black sulphuret of lead. The reaction of a monosulphuret of potassium on oxide of lead is as follows:—$PbO + KS = PbS + KO$. If the oxide of lead be combined with an acid, this unites with the potash, KO, to form a salt. If a polysulphuret of potassium, say tersulphuret, KS^3, be substituted for the monosulphuret, two equivalents of sulphur, S^2, are disengaged. The brown or black incrustation of sulphuret of lead (see *ante*, p. 483) is to be removed, while the patient is in the bath, by the use of a good stiff flesh brush and soap and water. The patient should be then re-dipped in the sulphurated bath, and the scrubbing process again resorted to. These proceedings should be continued until the skin no longer becomes discoloured by the sulphurated bath. In this way the lead deposited on the skin is rendered insoluble and inert, and its absorption prevented. In a few days it will be found that the sulphurated bath will again give rise to the dark incrustation, a fact which proves that either the lead is excreted by the skin (see *ante*, p. 186, foot-note), or that a portion of the lead had before escaped the action of the sulphurated solution. These baths, therefore, should be repeated every few days for several weeks,—until, in fact, their use is unattended with discolouration of skin.[1] By these means, relapses of the malady, arising from the absorption of this metal from the cutaneous surface, are prevented.

The internal antidotal treatment consists in the use of water acidulated with sulphuric acid (*sulphuric lemonade*), or of solutions of the soluble alkaline and earthy sulphates (sulphates of soda or magnesia, or alum). Mr. Benson[2] used with great benefit, as a preventive for the workers in lead, treacle beer acidulated with sulphuric acid; the formula for which is as follows:—

Treacle, 15 lbs.; Bruised Ginger, ½ lb.; Water, 12 gallons; Yeast, 1 quart; Bicarbonate of Soda, 1½ oz.; Oil of Vitriol, 1½ oz. by weight. Boil the ginger in two gallons of water, add the treacle and the remainder of the water (hot), put the whole in a barrel, and add the yeast. When the fermentation is nearly over, add the oil of vitriol, previously mixed with eight times its weight of water: lastly, the soda dissolved in one quart of water. It is fit for use in three or four days. The soda gives briskness, and, saturating one half of the acid, forms sulphate of soda.

Instead of sulphuric acid and the sulphates, Chevallier and Rayer proposed the use of the sulphurous or hepatic waters (see *ante*, p. 298), or an artificially prepared solution of sulphuretted hydrogen (see *ante*, p. 364), or sulphuret of potassium (see *ante*, p. 482). But as before stated, the practical success was not in proportion to the theoretical anticipations.

Besides the treatment of lead poisoning by chemical antidotes, other remedial agents usually require also to be employed, especially cathartics and opiates. The best cathartics (in addition to the sulphates above mentioned) are castor and croton oils; though many practitioners rely on a combination of sulphate of magnesia and senna. Croton oil, which was recommended by Dr. Kinglake, has proved most successful in the hands of Rayer, Tanquerel, Andral, and others. Opium is used with great benefit to relieve pain and cramps. When vomiting is very troublesome, and liquid medicines do not remain on the stomach, we may give the compound extract of colocynth or croton oil, with opium, in the form of pill. In several cases in which the pulse was full and strong, the face flushed, and the tongue furred and dry, I have used blood-letting with evident advantage.

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[1] Dana, *Lead Diseases*, p. 360; also, Bennett, *Lancet*, April 1846.

[2] *Lancet*, Dec 17, 1842.

In the after-treatment of lead paralysis there are two important remedies which deserve trial, namely strychnia, or the alcoholic extract of nux vomica, and electricity. They require to be cautiously but perseveringly employed. Mercury has been recommended by Dr. Clutterbuck.

122. PLUMBI OXYDUM.—OXIDE OF LEAD.

Formula PbO. *Equivalent Weight* 112.

HISTORY.—The ancients were acquainted with oxide of lead. Hippocrates[1] employed the semi-vitrified oxide (*litharge*, λιθάργυρον). Dioscorides[2] and Pliny[3] both mention litharge: the latter calls it *molybdæna*.

PREPARATION.—Lead, when heated in the air so as to be converted into vapour, burns with a white light and forms oxide of lead, which, when thus obtained, is called *flowers of lead* (*flores plumbi*). If melted lead be exposed to a current of air, it is rapidly oxidated and converted into the protoxide of this metal. The oxidated skimmings are denominated *massicot*. These, when fused at a bright red heat, are separated from some intermixed metallic lead; the fused oxide forms, on solidifying, a brick-red mass, which readily separates into crystalline scales: these constitute *litharge* (*lithargyrum*).

Litharge is obtained as a secondary product in the cupellation of argentiferous lead. The alloy is melted on a porous vessel, called a *test* or *cupel* (*cineritium*), and exposed to the blast of a bellows, by which the lead is oxidized, half vitrified, and driven off into hard masses of a scaly texture, and in that state is called *litharge* or *silver stone*.[4]

PROPERTIES.—Oxide of lead appears to be both dimorphous and amorphous. Thus it occurs in the form of pale yellow rhombic octohedra (dodecahedra?), in that of red cubes, and also in that of a red amorphous powder. Both Houton-Labillardière and Payen have obtained anhydrous oxide of lead in the form of white crystals.

Oxide of lead may be white, yellow, or reddish, according to the mode of preparation. As usually met with it is a pale yellow or reddish-yellow powder. There are several commercial forms of it. One of these is yellow, and is termed *massicot* (*cerussa citrina*). When semivitrified (*plumbi oxydum semivitreum*), it is called *litharge* (*lithargyrum*). This occurs in the form of small yellow or reddish scales or flakes, and, according to its colour, is called *gold litharge* (*lithargyrum aureum vel chrysitis*;) or *silver litharge* (*lithargyrum argenteum vel argyritis*).

According to Leblanc red or gold litharge does not owe its colour to the presence of minium; for if it be melted and cooled suddenly it remains yellow, whereas if it be cooled slowly it acquires a red colour.

Oxide of lead is fusible, and at a very high temperature volatile. It is almost insoluble in water. It is said that this liquid will take up about

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[1] *De Morb. Mul.* ii.
[2] Lib. v. cap. cii.
[3] *Hist. Nat.* xxxiv. 53.
[4] Watson's *Chem. Essays*, iii. 325, 6th edit.

$\frac{1}{7000}$th part of oxide, and that it acquires therefrom alkaline properties. Oxide of lead combines with alkalies and earths, forming salts called *plumbites*.

Characteristics.—Heated on charcoal by the blowpipe, it is readily reduced to the metallic state. It is blackened by hydrosulphuric acid, forming sulphuret of lead, PbS. It dissolves in dilute nitric acid, forming a solution of nitrate of lead, PbO,NO^5, whose characteristic properties have been already stated (see *ante*, p. 727). The varieties of the oxide are distinguished by their physical peculiarities.

Composition.—Oxide of lead is thus composed :—

	Atoms.	*Eq. Wt.*	*Per Cent.*	*Berzelius.*	*Berthier.*
Lead	1	104	92·857	92·828	93·3
Oxygen	1	8	7·143	7·172	6·7
Oxide of Lead	1	112	100·000	100·00	100·0

Purity.—It is not subject to adulteration.

Almost entirely soluble in dilute nitric acid, Its other properties are the same as those of carbonate of lead.—*Ph. Lond.*

Fifty grains dissolve entirely, without effervescence, in a fluidounce and a half of pyroligneous acid; and the solution, precipitated by 53 grains of phosphate of soda, remains precipitable by more of the test.—*Ph. Ed.*

The presence of a carbonate would be indicated by effervescence on the addition of acetic acid.

Physiological Effects.—Inhaled in the form of vapour or fine dust, it produces the before-mentioned constitutional effects of lead (see *ante*, pp. 187 and 727).

The effects of this substance, when swallowed, are but little known. It possesses very slightly irritant properties. "The experimentalists of Lyons found litharge to be irritant in large doses of half an ounce."[1]

From its external use ill consequences have sometimes resulted.

Uses.—Oxide of lead is never employed internally. Litharge is sometimes sprinkled over ulcers, as an astringent and desiccating substance. In pharmacy, it is used in the preparation of *emplastrum plumbi, ceratrum saponis, acetas plumbi,* and *liquor plumbi diacetatis.*

1. PLUMBI OXYDUM HYDRATUM, L.; *Hydrated Oxide of Lead* (Solution of Diacetate of Lead, Ovj.; Distilled Water, *Cong.* iij.; Solution of Potash, Ovj., or as much as may be sufficient to precipitate the oxide. Mix. Wash with water what is precipitated, until nothing alkaline remains). According to Winkelblech[2] the white precipitate obtained by adding excess of potash to a solution of an acetate of lead is not the hydrated oxide of lead, but the *hexacetate of lead*, $6PbO,\bar{A},3HO$.

The precipitate is a white powder, which is soluble in a considerable excess of caustic potash.

Hydrated oxide of metal consists of three equivalents of oxide of lead and one equivalent of water, $3PbO,HO$.

What is used in preparing disulphate of quina should be totally dissolved by dilute nitric acid. Its remaining properties resemble those of the preceding.—*Ph. Lond.*

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[1] Christison, *op. cit.* p. 509.

[2] L. Gmelin, *Handb. d. Chemie*, Bd. iv. S. 642, 4te Aufl. 1848.

It is directed, by the London College, to be employed in the preparation of *quinæ disulphas.*

2. **CALCIS PLUMBIS**; *Plumbite of Lime.*—This is prepared by boiling oxide of lead with cream of lime. Plumbite of lime is employed as a *hair dye,* (see *ante,* p. 156). The lead of the plumbite unites with the sulphur contained in the organic substance composing the hair, and forms the black sulphuret of lead.

123. PLUMBI OXYDUM RUBRUM.—RED OXIDE OF LEAD.

Formula $Pb^3O^4 = 2PbO,PbO^2$. *Equivalent Weight* 344.

HISTORY.—It is doubtful whether the ancients were acquainted with this compound, as the substance which Pliny[1] called *minium* was cinnabar. He describes, however, an inferior kind, which he terms *minium secundarium,*[2] and which may be, perhaps, the red oxide of lead. Dioscorides[3] distinguished minium from cinnabar.

Besides *minium,* there are several other names for red oxide of lead. In commerce it is usually known as *red lead.* It is sometimes termed *deutoxide of lead,* or the *plumbate of the oxide of lead.*

NATURAL HISTORY.—*Native minium* is found in Yorkshire, Suabia, Siberia, and some other places.

PREPARATION.—Red lead is prepared by subjecting protoxide of lead (massicot or litharge) to the combined influence of heat and air. It absorbs oxygen and is converted into red lead. A heat of about 600° is necessary. The finest minium is procured by calcining the oxide of lead obtained from the carbonate.[4]

PROPERTIES.—Red oxide of lead has a brilliant red colour. By heat it gives out oxygen gas, and is converted into the protoxide of lead. Its sp. gr. is 8·62.

Characteristics.—By a strong heat it is converted into oxygen gas and the yellow oxide (PbO). Before the blowpipe on charcoal it yields first the yellow protoxide, and then metallic lead. When digested in nitric acid, the nitrate of the protoxide is obtained in solution, while the insoluble brown or peroxide of lead, PbO^2, remains. By the action of sulphurous acid on red lead, white sulphate of the protoxide is obtained. $2PbO,PbO^2 + SO^2 = 2PbO + PbO,SO^3$.

"Entirely soluble in highly-fuming nitrous acid; partially soluble in diluted nitric acid, a brown powder being left."—*Ph. Ed.*

COMPOSITION.—The composition of real or pure red lead is as follows:—

	Atoms.	*Eq. Wt.*	*Per Ct.*	*Berzelius.*	*Dumas.*
Lead	3	312	90·7	90	90·63
Oxygen	4	32	9[illegible]	10	9·37
Red Lead	1	344	100·0	100	100·00

or

	Atoms.	*Eq. Wt.*	*Per Ct.*	*Dumas.*
Protoxide	2	224	65·12	64·9
Peroxide	1	120	34·88	35·1
	1	344	100.00	100·0

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[1] *Hist. Naturalis,* lib. xxxiii. cap. 40, ed. Valp.

[2] *Idem.*

[3] Lib. v. cap. 109.

[4] Graham, *Elements of Chemistry,* p. 589.

Dumas[1] has shown that red lead of commerce is not uniform in composition, but consists of variable mixtures of real red lead with protoxide. His results have been confirmed by those of Mr. Phillips.[2] That real red lead is not a mere mixture of protoxide and peroxide is apparently shown by its colour, as well as by the fact that it is not altered by heating it in a solution of acetate of lead, which is capable of dissolving free protoxide. The following formulæ represent the composition of different specimens of minium: $2PbO,PbO^2$; PbO,PbO^2; $5PbO,PbO^2$; $3PbO,PbO^2$.

ADULTERATION.—Commercial red lead is sometimes adulterated with earthy substances (as brick dust), red oxide of iron, &c. Gélis and Fordos propose to detect this by boiling the suspected minium in water, with sugar, and a small quantity of nitric acid. The minium is entirely dissolved if it be pure, leaving the foreign matters.

PHYSIOLOGICAL EFFECTS AND USES.—Its effects are similar to the protoxide of lead. It is but little employed in pharmacy. The Edinburgh College directs it to be employed in the preparation of *aqua chlorinii* (see *ante*, p. 373).

124. PLUMBI CARBONAS.—CARBONATE OF LEAD.

Formula PbO,CO^2. *Equivalent Weight* 134.

HISTORY.—*Ceruse* (*cerussa*), or *white lead*, was known to the ancients. The Greeks called it ψιμύθιον, or ψιμμύθιον, and later ψιμίθιον. It was employed by Hippocrates[3] in medicine. Theophrastus[4] describes the method of preparing it by exposing lead to the fumes of vinegar in earthen vessels. Dioscorides[5] and Pliny[6] also notice this mode of procuring it.

Besides the preceding, white lead has also been known by other names, such as *magistery of lead* (*magisterium plumbi*), *flake white*, *subcarbonate of lead*, &c.

NATURAL HISTORY.—Neutral or monocarbonate of lead is found native, both crystallized and massive, in Scotland, England, &c. It is called *white lead ore*.

PREPARATION.—Various methods are described for the preparation of carbonate of lead, but the products obtained by some of the processes differ from those procured by others.

1. *Neutral carbonate of lead* is obtained by adding a solution of an alkaline carbonate to a solution of acetate or nitrate of lead. If acetate of lead and carbonate of potash be employed, the reactions are as follows:—$PbO,\bar{A}+KO,CO^2=KO,\bar{A}+PbO,CO^2$. Procured in this way it is deficient in *body*, owing to the transparency of the crystalline grains; and it is not, therefore, fitted for the use of the painter, who requires a dense and opaque carbonate. The compounds which possess the required properties expressed

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[1] *Ann. de Chim. et de Phys.* xlix. 398.

[2] *Phil. Mag.* N.S. iii. 125.

[3] *De Morbis*, lib. ii.

[4] Theophrastus's *History of Stones*, by Sir J. Hill, 2d edit. p. 223, Lond, 1774.

[5] Lib. v. cap. ciii.

[6] *Hist. Nat.* lib. xxxiv.

by the term body, are basic carbonates, composed of the neutral carbonate and the hydrated oxide.

2. *Basic carbonate of lead,* called in commerce *ceruse,* or *white lead,* is prepared in various ways.

a. By decomposing a subsalt of lead by a stream of carbonic acid. At Clichy, in France, it is obtained by transmitting a stream of carbonic acid through a solution of subacetate of lead. The precipitate, according to Hochstetter, consists of $2(PbO,CO^2)+PbO,HO$. Pelouze and Fremy[1] represent it as the neutral carbonate: $3PbO,\bar{A}+2CO^2=2(PbO,CO^2)+PbO,\bar{A}$. The residual neutral acetate of lead is boiled with excess of litharge, and thereby converted into the tribasic acetate, which is used for the preparation of another portion of white lead.

A modification of the process has been employed by Messrs. Gossage and Benson, of Birmingham. Finely powdered litharge is moistened, mixed with about $\frac{1}{100}$th part of acetate of lead, and decomposed, during constant stirring, by carbonic acid.

Messrs. Button and Dyer substituted subnitrate of lead for subacetate, and decomposed by carbonic acid.

In all the above processes, the carbonic acid used may be obtained by the combustion of coke, or from a lime-kiln.

b. By exposing plates, or bars, or other forms of lead, to the vapour of acetic acid, and, at the same time, to air loaded with carbonic acid gas.

In this country white lead is extensively manufactured by the old or *Dutch* process, which, it is said, yields a product superior as an oil pigment to that obtained by most other methods.

"In the *Dutch process,* introduced into England about 1780, lead is cast into plates or bars, or into the form of stars, or circular gratings of six or eight inches in diameter, and from a quarter to half an inch in thickness:[2] five or six of these are placed one above another in the upper part of a conical earthen vessel something like a garden-pot, in the bottom of which there is a little strong acetic acid. These pots are then arranged side by side, on the floor of an oblong brick chamber, and are imbedded in a mixture of new and spent tan (ground oak bark used in the tan-yard). The first layer of pots is then covered with loose planks, and a second range of pots imbedded in tan is placed upon the former; and thus a stack is built up so as entirely to fill the chamber with alternate ranges of the pots containing the lead and acetic acid, surrounded by, and imbedded in, the tan. Several ranges of these stacks occupy each side of a covered building, each stack containing about 12,000 of the pots, and from 50 to 60 tons of lead. Soon after the stack is built up the tan gradually heats or ferments, and begins to exhale vapour, the temperature of the inner parts of the stack rising to 140° or 150°, or even higher. The acetic acid is slowly volatilized, and its vapour passing readily through the gratings or folds of lead, gradually corrodes the surface of the metal, upon which a crust of subacetate is successively formed and converted into carbonate, there being an abundant supply of carbonic acid furnished by the slow fermentative decomposition of the tanners' bark. In the course of from four to five weeks[3] the process is completed, and now, on unpacking the stacks, the lead is found to have undergone a remarkable change: the form of the castings is retained, but they are converted, with considerable increase of bulk, into dense masses of carbonate of lead: this conversion is sometimes entire, at others it penetrates only to a certain depth, leaving a central skeleton as it were of metallic lead, the conversion being unequal in different parts of the stack, and varying in its perfection at different seasons, temperatures, and states of the atmosphere. The stacks are so managed that they are successively being built up and unpacked. The corroded and converted gratings or cakes are then passed through rollers,[1] by which the carbonate of lead (*white lead*) is crushed and broken up, and the central core of metallic lead (*blue lead*), if any remain, is easily separated: the white lead is then transferred to the mills, where it is ground up into a thin paste with water, and is ultimately reduced, by the process of elutriation or successive washings and subsidences, to the state of an impalpable powder; it is then dried in wooden bowls, placed upon shelves in a highly heated stove, and thus brought to the state of masses easily rubbed between the fingers into a fine powder, in which the microscope does not enable us to discern the slightest traces of crystalline character (Brande)."

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[1] *Cours de Chimie Générale,* t. 2nde, p. 487, 1848.

[2] At one manufactory which I inspected, the lead was cast into rectangular gratings on a wooden mould. In the act of cooling the metal underwent crystallization; a change which I was informed was essential to the success of the process, as hammered or rolled lead does not so readily become corroded as the crystallized cast metal.

[3] At the manufactory before alluded to, I was informed that the process required from six to twelve weeks.

"If intended for the use of the painter, it is next submitted to grinding with linseed oil; and it is found that a hundred-weight of this white lead is formed into a proper consistence with 8 pounds of oil, whereas precipitated white lead requires 16 pounds of oil for the same purpose; the one covering the surface so much more perfectly, and having so much more body than the other."

"It is sometimes supposed in this process that the oxygen and carbonic acid required to form the carbonate of oxide of lead are derived from the decomposition of the acetic acid; but this is evidently not the case, for not more than 100 pounds of real acetic acid exist in the whole quantity of the diluted acid contained in the several pots of each stack; and in 100 pounds of acetic acid there are not more than 47 to 48 pounds of carbon, whereas 6740 pounds would be required to furnish the carbonic acid which should convert 50 tons of lead (the average weight of that metal in each stack) into carbonate of lead. There can be no doubt, then, that the carbon or carbonic acid must come from the tan, and that the oxygen is partly derived from the same source, and partly from the atmosphere: the principal action of the acetic acid therefore is to form successive portions of subacetate of lead, which are successively decomposed by the carbonic acid: the action is, however, of a very remarkable description, for even masses of lead, such as blocks of an inch or more in thickness, are thus gradually converted through and through into carbonate, so that if due time is allowed there is no central remnant of metallic lead. The original texture of the lead is much concerned in the extent and rapidity of the conversion. Rolled or sheet lead will not answer, and the gratings, coils, and stars, which are employed, are all of cast-lead. The purest metal is also required; for if it contain iron, the resulting white lead acquires a tawny hue, and if a trace of silver, it acquires a perceptible dinginess when it is subjected to the action of light (Brande)."

The presence of copper in the lead also alters the appearance of the resulting white lead.

A minute quantity of lamp black, indigo, or some other blue pigment, is usually added to white lead at the time of grinding it with oil, to destroy the yellow tint.

By conversion into white lead, the metal usually gains an increase in weight of about a fourth part.

3. By the mutual action of lead, water, and carbonic acid, a basic carbonate of lead is produced.

The crust formed in leaden cisterns, leaden pipes, &c. by the action of a pure water and air containing carbonic acid, is of this kind (see pp. 283 and 739).

Some years ago a manufactory for white lead, founded on this principle, was established at Pimlico, but it was soon abandoned. Granulated lead was agitated in water, and the resulting hydrated oxide of lead was exposed to the action of carbonic acid (Brande).

PROPERTIES.—Both the carbonate and subcarbonates of lead are white, effervesce with nitric acid, are blackened by sulphuretted hydrogen or the hydrosulphurets, give out their carbonic acid, and are converted into the yellow oxide, when heated. By the aid of carbonic acid they are very slightly soluble in water.

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[1] In some manufactories, the white lead is separated by hand from the residual metallic lead.

α. *Of the neutral carbonate* (PbO,CO^2).—The native carbonate is found crystallized in forms derived from a right rhombic prism (see *ante*, fig. 39, p. 141). The artificial carbonate is a white powder.

β. *Of the subcarbonates.*—These are compounds of the neutral carbonate with the hydrated oxide. They are dull, white, and dense. They possess great covering power, or *body*. The dicarbonate ($2PbO,CO^2,HO$), however, does not, according to Bonsdorff, possess the covering power of common white lead. The smaller the quantity of hydrated oxide present, the less readily does the subcarbonate become yellow or brownish by exposure to air and light. Examined by the microscope, none of the subcarbonates present any traces of crystalline texture.

Characteristics.— Heated on charcoal by the blowpipe flame, the carbonates of lead yield soft malleable globules of metallic lead, usually surrounded by a small quantity of the yellow oxide (PbO). Sulphuretted hydrogen and the hydrosulphurets blacken them (PbS). They dissolve in nitric acid with effervescence: the characters of the nitric solution have been before stated (see *ante*, p. 727).

The neutral carbonate and subcarbonates are distinguished from each other by quantitative analysis.

COMPOSITION.—All these compounds contain carbonic acid (CO^2) combined with oxide of lead (PbO). Some of them also contain the hydrated oxide (PbO,HO). The proportion of carbonate to hydrate appears to be very different in different preparations.

α. *Of the neutral or monocarbonate.*—The composition of the native as well as of the artificial salt is as follows:—

	Atoms.	*Eq. Wt.*	*Per Cent.*	*Klaproth.* (Native.)	*Berzelius.* (Artificial.)
Oxide of Lead	1	112	83·58	83·67	83·46
Carbonic Acid	1	22	16·42	16·33	16·54
Carbonate of Lead	1	134	100·00	100·00	100·00

β. *Of the subcarbonates.*—These are not uniform in composition.

According to both Bonsdorff and Yorke, the crust formed on lead by the united influence of water and carbonic acid is a *dicarbonate*.

	Atoms.	*Eq. Wt.*	*Per Cent.*	*Bonsdorff.*	*Yorke.*
Oxide of Lead	2	224	87·85	86·51	89·00
Carbonic Acid	1	22	8·62	9·93	7·66
Water	1	9	3·53	3·55	2·83
Dicarbonate of Lead	1	255	100·00	99·99	99·49

Its composition, therefore, may be thus stated:—$PbO,CO^2 + PbO,HO$.

Dr. Christison found the composition of the crust formed on lead by the united agencies of air and water to be $3PbO,2CO^2,HO = 2(PbO,CO^2) + PbO,HO$.

Commercial white lead appears to be somewhat variable in composition. In a general way its composition may be stated as $3PbO,2CO^2,HO$, or $2(PbO,CO^2) + PbO,HO$. But the proportion of hydrated oxide is sometimes less than this.

				Hockstetter.		*Mulder.*		
	Atoms.	*Eq.Wt.*	*Per Ct.*	Magdeburgh manufacture, by French process.	Harz manufacture.	Dutch.	English.	Kremser, white.
Oxide of Lead	3	336	86·38	85·87	86·42	86·59	86·16	86·31
Carbonic Acid	2	44	11·31	11·77	11·51	11·71	11·91	11·35
Water	1	9	2·31	2·14	2·23	2·11	1·93	2·16
White Lead	1	389	100·00	99·78	100·16	100·41	100·00	99·82

In other samples the proportion of hydrated oxide appeared to be less than this. In some Mulder found $5(PbO,CO^2)+2(PbO,HO)$: in others $2(PbO,CO^2)+1(PbO,HO)$. Richardson[1] analysed ten samples of white lead, and found that when dried at 300° F. the per centage quantity of oxide of lead varied from 83·49 to 86·45, and of carbonic acid from 15·83 to 12·99.

PURITY.—Carbonate of lead of commerce is rarely pure. It is usually adulterated with earthy or metallic sulphates (as of lime, baryta, or lead). These are detected by their insolubility in diluted nitric acid. Chalk (which is by some used to adulterate it) may be detected as follows:—Dissolve the suspected substance in nitric acid, and precipitate the lead by hydrosulphuric acid. Boil and filter the solution, in which will be contained nitrate of lime (if chalk had been present), recognizable by oxalic acid or oxalate of ammonia (see *ante*, p. 581).

Minute portions of lamp black, indigo, or Prussian blue, are added to improve the whiteness of the commercial article. Sometimes a minute portion of the hexacetate of lead $6PbO,\bar{A}$ is found in commercial white lead.

Dissolved with effervescence in dilute nitric acid. What is precipitated from the solution by potash is white, and is re-dissolved by excess of it: it becomes black on the addition of hydrosulphuric acid. It becomes yellow by heat, and, with the addition of charcoal, it is reduced to metallic lead. *Ph. Lond.*

It does not lose weight at a temperature of 212°: 68 grs. are entirely dissolved in 150 minims of acetic acid diluted with a fluidounce of distilled water; and the solution is not entirely precipitated by a solution of 60 grs. of phosphate of soda. *Ph. Ed.*

PHYSIOLOGICAL EFFECTS.—Its *local* effects are not very powerful: applied to ulcerated surfaces it acts as a desiccating and astringent substance: swallowed in large quantities it does not act as a local irritant, like the acetate. Its *constitutional* effects are similar to those of the other preparations of lead already described. It appears (see *ante*, p. 729) that carbonate of lead more frequently produces colic than the acetate of lead—a circumstance which Dr. Christison thinks may be owing to the great obstinacy with which its impalpable powder adheres to moist membranous surfaces, and the consequent greater certainty of its ultimate absorption.

USES.—It is never administered internally.

Externally it is employed as a dusting powder in excoriations of children and lusty persons; but the practice is objectionable, on account of the danger of absorption. In one case, related by Kopp,[2] a child was destroyed by it. An ointment or plaster of carbonate of lead has been known to give relief in some cases of neuralgia.[3]

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[1] Graham's *Elements of Chemistry*, p. 591.

[2] Richter, *Ausf. Arzneim.* iv. 613.

[3] *Journ. de Pharm.* xx. 603.

UNGUENTUM PLUMBI CARBONATIS, *E. D.*; *Ointment of Carbonate of Lead.* (Simple Ointment, ℥v.; Carbonate of Lead, ℥j. *E.*—Carbonate of Lead, reduced to very fine powder, ℥ij.; Ointment of White Wax, lbj. *D.* Mix.)—This ointment is valuable as a cooling and desiccating application to excoriated surfaces or burns.

125. PLUMBI CHLORIDUM.—CHLORIDE OF LEAD.

Formula PbCl. *Equivalent Weight* 139·5.

HISTORY.—This compound was formerly called *plumbum corneum* or *horn lead.*

NATURAL HISTORY.—Native chloride of lead (PbCl), called *cotunnite,* occurs in acicular crystals in the crater of Mount Vesuvius.

Corneous lead, also called *chloro-carbonate of lead,* is found near Matlock in Derbyshire, and at other places. Its formula is $PbCl + PbO,CO^2$.

Mendipite or *oxichloride of lead* has been found at Churchill, in the Mendip Hills of Somersetshire. Its formula is PbCl,2PbO.

PREPARATION.—In the London Pharmacopœia chloride of lead is directed to be prepared as follows:—

Take of Acetate of Lead, ℥xix.; Distilled Water, boiling, Oiij.; Chloride of Sodium, ℥vj. Dissolve the Acetate of Lead and Chloride of Sodium separately, the former in three pints of Distilled Water, and the latter in one pint of Distilled Water. Then the liquors being mixed together, wash what is precipitated with distilled water when it is cold, and dry it.

In this process one equivalent of acetate of lead is decomposed by one equivalent of chloride of sodium; one equivalent of chloride of lead is precipitated, and one equivalent of acetate of soda remains in solution $PbO,\bar{A} + NaCl = PbCl + NaO,\bar{A}$. Hydrochloric acid occasions the precipitation of more chloride of lead after the action of chloride of sodium is over; so that there must be some compound of lead in solution.[1]

PROPERTIES.—It is a white crystalline powder (*magisterium plumbi vel magisterium saturni crollii*), soluble in thirty parts of cold or twenty-two parts of boiling water. When heated it fuses; and by cooling forms a semi-transparent horny-like mass, called *horn lead* (*plumbum corneum*).

Characteristics.—Its aqueous solution causes a white precipitate with nitrate of silver, soluble in ammonia but insoluble in nitric acid; hence it is shown to be a chloride. The solution is known to contain lead by the before-mentioned tests for this metal (see *ante,* p. 726).

Totally dissolved by boiling water, the chloride concreting almost entirely into crystals as it cools. On the addition of hydrosulphuric acid it becomes black, and by heat yellow. —*Ph. Lond.*

COMPOSITION.—The following is its composition:—

	Atoms.	*Eq. Wt.*	*Per Cent.*	*J. Davy.*	*Döbereiner.*
Lead	1	104	74·55	74·22	75·76
Chlorine	1	35·5	25·45	25·78	24·24
Chloride of Lead	1	139·5	100·00	100·00	100·00

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[1] Phillips, *Transl. of Pharm.* 4th edit.

Physiological Effects.—Chloride of lead acts topically as an astringent and caustic. It combines with the albumen and fibrine of the animal tissues and fluids, forming compounds insoluble in water. It is also stated to have a paralysing and anodyne local effect. After its absorption it produces the usual effects of the compounds of lead, and which have been already described (see *ante*, p. 727).

Uses.—According to Mr. Tuson[1] it is a valuable agent in the treatment of cancerous affections. It both allays pain and restrains morbid action. In hysterical hyperæsthesia of the breast, and in cases where pain is excited by the pressure of a tumour on the nerves of the part, it proves highly successful. It is also useful in allaying inflammation.

Use.—It is employed in the form both of solution and of ointment. The *solution* is prepared by dissolving one drachm of the chloride in a pint of water. The *ointment* consists of ʒj. of chloride and ℥j. of simple cerate.

Antidotes.—See *ante*, p. 731.

126. PLUMBI IODIDUM.—IODIDE OF LEAD.

Formula PbI. *Equivalent Weight* 230.

History.—This compound was introduced into medicine by Cottereau and Verdé Delisle.

Preparation.—The London and Edinburgh Colleges give directions for the preparation of it.

The *London College* orders of Acetate of Lead, ℥ix.; Iodide of Potassium, ℥vij.; Distilled Water, *cong*. j. Dissolve the Acetate of Lead in six pints of the Water, and strain; and to these add the Iodide of Potassium first dissolved in two pints of the water. Wash what is precipitated, and dry it.

By the mutual action of one equivalent of dry acetate of lead, and one equivalent of iodide of potassium, we obtain one equivalent of iodide of lead and one equivalent of acetate of potash. $PbO,\bar{A} + KI = PbI + KO,\bar{A}$ The reacting proportions of iodide of potassium and crystallized acetate of lead are 165 parts of the former and 190 parts of the latter. Hence the London College uses an excess of iodide, supposing the acetate to be neutral. This excess is disadvantageous, since it retains a portion of the iodide of lead in solution ($2KI,3PbI$).

If excess of acetate of lead be employed, a portion of oxiodide of lead (PbI,PbO) precipitates along with the iodide.

If the acetate of lead employed to decompose the iodide of potassium, be contaminated with subacetate (as the sugar of lead of commerce usually is) a portion of oxiodide of lead (PbI,PbO) precipitates along with the iodide. This may be prevented by carefully saturating the subacetate with acetic acid But if excess of acetic acid be used, the precipitated iodide of lead contains a slight excess of iodine (*superiodide of lead ?*).

The *Edinburgh College* orders of Iodide of Potassium, and Nitrate of Lead, of each, ℥j.; Water, Oiss.; dissolve the salts separately, each in one half of the water; add the solutions; collect the precipitate on a filter of linen or calico, and wash it with water. Boil the powder in three gallons of water acidulated with three fluidounces of pyroligneous acid. Let any undissolved matter subside, maintaining the temperature near the boiling point; and pour off the clear liquor, from which the iodide of lead will crystallize on cooling.

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[1] *Lancet*, Jan. 13, 1844.

By the mutual reaction of nitrate of lead and iodide of potassium we obtain nitrate of potash and iodide of lead. $PbO,NO^5 + KI = PbI + KO,NO^5$. The reacting proportions are one atom or 166 parts of nitrate of lead, and one atom or 165 parts of iodide of potassium; or nearly equal weights of the materials, as ordered by the College.

For pharmaceutical purposes, especially for the preparation of ointments, the pulverulent iodide is preferable to the crystalline or scaly kind.

PROPERTIES.—It is a fine yellow powder, very sparingly soluble in cold water, but readily soluble in boiling water; from which it for the most part separates, as the solution cools, in the form of golden yellow, brilliant, small scales. It is fusible. It combines with the alkaline iodides, forming a class of double salts, called the *plumbo-iodides* or *iodo-plumbates*. Caustic potash dissolves it, and forms a plumbo-iodide of potassium and plumbate of potash.[1] It is soluble in acetic acid and in alcohol.

Characteristics.—When heated, it first forms a yellow vapour (*iodide of lead*), and afterwards a violet vapour (*iodine*), leaving a residue (*lead*), which, when dissolved in nitric acid, gives all the characters of solution of lead (see *ante*, p. 726). Boiled with carbonate of potash, it forms carbonate of lead and iodide of potassium.

COMPOSITION.—Its composition is as follows:—

	Atoms.	*Eq. Wt.*	*Per Cent.*	*Henry.*
Lead	1	104	45·21	45·1
Iodine	1	126	54·78	54·9
Iodide of Lead	1	230	99·99	100·0

PURITY.—It should be completely soluble in boiling water.

Totally dissolved by boiling water, and as it cools separates in shining yellow scales. It melts by heat, and the greater part is dissipated first in yellow, and afterwards in violet vapours.—*Ph. Lond.*

Bright yellow: five grains are entirely soluble, with the aid of ebullition, in one fluidrachm of pyroligneous acid, diluted with a fluidounce and a half of distilled water; and golden crystals are abundantly deposited on cooling.—*Ph. Ed.*

PHYSIOLOGICAL EFFECTS. α. *On Animals.*—Twenty-four grains of iodide of lead were given to a cat at two doses, with an interval of four hours: the animal suffered violent colic, and died in three days; but no signs of irritation were observed after death.[2] Iodide of lead was given in doses of from gr. v. to ʒss. to a bull-dog: no effect was observed until the fifteenth day, when the animal refused food, and kept in the recumbent posture. He died on the eighteenth day, having swallowed altogether ten drachms and fifty grains of iodide. During the whole period he had only three or four intestinal evacuations.[3]

β. *On Man.*—Its effects on man have been imperfectly determined. It does not appear to act as an irritant when applied to the skin or ulcerated surfaces. Under the continued external and internal use of it, enlargements of the lymphatic glands have disappeared, from which we infer a specific influence over the glandular and lymphatic system. In some cases it appeared to occasion irritation of the stomach. I have seen constipation induced by it. After its medicinal use for several weeks I have not observed any blue line on the gums.

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[1] Dumas, *Traité de Chim.* iii. 379.

[2] Paton, *Journ. de Chim.* iii. 41, 2nde Sér.

[3] Cogswell, *Essay on Iodine*, 143.

USES.—It has been principally employed to reduce the volume of indolent tumours, especially enlargements of the cervical, axillary, inguinal, and mesenteric glands, both scrofulous and syphilitic. In these cases it should be simultaneously employed internally and externally. I have also given it in suspected incipient phthisis. I have used it in two cases of enlarged cervical glands, but without benefit. Velpeau[1] and others, however, have been more successful.

ADMINISTRATION.—The dose is three or four or more grains. Dr. O'Shaughnessy[2] says, ten-grain doses are easily borne, without the slightest annoyance. Bally has given 30 grs. at a dose. It is administered in the form of pill.

UNGUENTUM PLUMBI IODIDI, L.; *Ointment of Iodide of Lead.* (Iodide of Lead, ℥j.; Lard, ℥viij. M.)—This is applied, by way of friction, to scrofulous and other indolent swellings.

127. PLUMBI NITRAS.—NITRATE OF LEAD.

Formula PbO,NO^5. *Equivalent Weight* 166.

HISTORY.—This salt was employed in medicine two centuries ago.[3] It has had various names; such as *nitrum saturninum, plumbum nitricum,* &c.

PREPARATION.—The Edinburgh College gives the following directions for its preparation:—

Take of Litharge, ℥ivss.; Diluted Nitric Acid, Oj. Dissolve the litharge to saturation with the aid of a gentle heat. Filter, and set the liquor aside to crystallize. Concentrate the residual liquid to obtain more crystals.

The nitric acid combines with the protoxide of lead to form the nitrate of this metal. $PbO + NO^5 = PbO,NO^5$.

PROPERTIES.—This salt crystallizes in regular octohedrons or modifications of these. Its solution in water is sweet and austere. The crystals decrepitate loudly by heat.

Characteristics.—When subjected to heat in a glass tube this salt decrepitates and evolves the reddish-brown vapour of nitrous acid. It possesses also the other characters of a nitrate which have been before stated (see *ante*, p. 412). It is known to be one of the plumbeous salts by the before-mentioned tests for these substances (see *ante*, p. 726).

COMPOSITION.—This salt is anhydrous. Its composition is as follows:—

	Atoms.	*Eq. Wt.*	*Per Cent.*	*Döbereiner.*	*Berzelius.*	*Svanberg.*
Oxide of Lead	1	112	67·47	67·6	67·2225	67·403
Nitric Acid	1	54	32·53	32·4	32·7775	32·597
Crystallized Nitrate Lead	1	166	100·00	100·0	100·0000	100·000

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[1] Lugol's *Essays*, by Dr. O'Shaughnessy, p. 206.

[2] *Ibid.* p. 207.

[3] Schroder's *Chymical Dispensatory*, by Dr. Rowland, pp. 199 and 255, Lond. 1669.

PHYSIOLOGICAL EFFECTS.—Its general effects are similar to those of the other soluble salts of lead (see *ante*, p. 726). Its local action on the animal tissues depends on its affinity for albumen and fibrin. In a solution of albumen it forms a white precipitate, composed, according to Lassaigne,[1] of *albumen*, 89·45, and *nitrate of lead*, 10·55. This precipitate is soluble in a great excess of albumen, as well as in solutions of ammonia and some neutral salts, as acetate of potash. Applied to mucous surfaces, wounds, and ulcers, it does not irritate, but promotes healthy secretions and the cicatrization of ulcers. It decomposes the chlorides, sulphates, and hydrosulphurets contained in animal fluids: its power of decomposing sulphuretted hydrogen and the hydrosulphurets (with which it forms sulphuret of lead, PbS) renders it useful as a deodorizer.

USES.—Two hundred years ago this salt was employed in medicine as a remedy for asthma.[2] In the last century it was administered to check hemorrhage;[3] and also in epilepsy.[4]

At the present time it is rarely used internally. In active hemorrhage from the lung I have sometimes prescribed a pill composed of sugar of lead and opium, and a mixture containing nitric acid: nitrate of lead would thus be formed in the stomach. With this combination I have succeeded in getting the system under the influence of lead in a much shorter time than by the use of sugar of lead only.

Its principal use is as a topical agent. It has been employed in the treatment of wounds, ulcers, cancerous diseases, and cutaneous maladies.

A solution of ten grains of nitrate of lead in an ounce of water, and coloured (probably with alkanet), constitutes Liebert's secret remedy for cracked nipples, and which is sold in Paris and Frankfort under the name of "*Cosmétique infaillible et prompt contre les gerçures ou crevasses aux seins et autres.*" Two very fine leaden nipple-shields are sold along with the solution. The solution is to be applied to the nipple, which is then to be covered with a shield; and this is to be repeated each time after the child has done sucking. The nipple is to be carefully washed with lukewarm water before the child is put to the breast. This mode of treatment has been tried by Dr. Volz,[5] and found to be most successful. He also speaks very favourably of the use of this solution in the treatment of chapped hands and cracked lips.

Ledoyen's disinfecting fluid is a solution of one drachm of nitrate of lead in an ounce of water. It completely destroys the unpleasant odour of animal and vegetable substances which are evolving sulphuretted hydrogen and hydrosulphuret of ammonia; but there is no evidence to show that it has any power of destroying miasmata.[6]

Le Maître de Rabodanges[7] has employed the nitrate both to destroy putrid effluvia and for the preservation of animal substances. Its antiseptic power, however, is denied by the Editor of the *Pharmaceutical Journal* (vol. vii. p. 115).

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[1] *Journ. de Chim. Méd.* t. vi. 2nde Série.

[2] Schroder, *op. cit.*

[3] *Act. Ac. Caes. Nat. Curios.* vol. i. obs. 16 (quoted by J. F. Gmelin); *Apparatus Medicamin.* vol. i. p. 419, 1795.

[4] A. Gesner and Oosterdyck Schacht, quoted by Aschenbrenner, *Die neuern Arzneimittel.* 1848.

[5] *Medicinische Zustände*, Pforzheim, 1839 (quoted by Dierbach, *Die neuesten Entdeckungen in der Mat. Med.* Bd. 2er, S. 1225, 1843).

[6] *Pharmaceutical Journal*, vol. vii. pp. 63 and 110, 1847.

[7] *Acad. des Sciences*, 8 Juin, 1846.

ADMINISTRATION.—Nitrate of lead may be administered internally in doses of from gr. ¼ to gr. j. twice or thrice daily in the form of pill or solution.

Externally, a solution of from 10 grs. to ʒj. of the salt in an ounce of distilled water is used.

Nitrate of lead was introduced into the Edinburgh Pharmacopœia as the best salt for the preparation of *iodide of lead* (see *ante*, p. 742).

128. PLUMBI ACETATES.—ACETATES OF LEAD.

Five compounds of acetic acid and oxide of lead are known: of these one is the neutral acetate, and the other four are basic salts.

Hexacetate (crystallized)	$6PbO,\bar{A},3HO$
Trisacetate	$3PbO,\bar{A}$
Diacetate	$2PbO,\bar{A}$
Sesquiacetate	$3PbO,2\bar{A}$
Neutral acetate (crystallized)	$PbO,\bar{A},3HO$.

Of these five acetates two only are employed in medicine, namely, the neutral acetate and the diacetate. The hexacetate is sometimes found in commercial white lead (see *ante*, p. 740).

1. Plumbi Acetas.—Neutral Acetate of Lead.

Formula $PbO,\bar{A}$. *Equivalent Weight* 163.

HISTORY.—Raymond Lully and Isaac Hollandus were acquainted with this salt in the 13th century. It has been known by several appellations, as *sugar of lead* (*saccharum saturni*), *acetated ceruse* (*cerussa acetata*), and *superacetate of lead* (*plumbi superacetas*).

PREPARATION.—Though directions are given in the British Pharmacopœias for its preparation, it is never made by the apothecary, but is procured from persons who manufacture it on a large scale.

The *London College* orders of Oxide of Lead, rubbed to powder, lbiv. and ℥ij.; Acetic Acid; Distilled Water, each, Oiv. Mix the acid with the water, and add the oxide of lead to them, and, a gentle heat being applied, dissolve it; then strain. Lastly, evaporate the liquor that crystals may form.

The *Edinburgh College* uses of Pyroligneous Acid (D. 1034) Oij.; Distilled Water, Oj.; Litharge, ℥xiv.

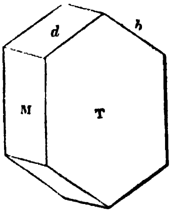
The *Dublin College* employs of Carbonate of Lead, named Ceruse, *any required quantity;* Distilled Vinegar, *ten times the weight of the Carbonate of Lead.*

In the above processes the protoxide of lead combines with acetic acid, and forms a definite compound. In the Dublin process carbonic acid is set free.

Acetate of lead is sometimes procured by partially immersing lead in pyroligneous or crude acetic acid. The metal attracts oxygen from the air, and the oxide thus formed unites with the acid. When leaden plates are exposed to the vapour of acetic acid in the air, they become incrusted with a mixture of subacetate and subcarbonate of lead. This being scraped off and dissolved in acetic acid, yields the crystallized acetate by evaporation. A brown or impure sugar of lead, made by digesting litharge in rough pyroligneous acid, is manufactured expressly for the use of dyers (Brande).

PROPERTIES.—The crystals of this salt belong to the oblique prismatic system. According to Mitscherlich, they are isomorphous with acetate of baryta, and belong to the right prismatic system. Their taste is sweetish and astringent. In a dry and warm atmosphere they slightly effloresce, and are apt to be decomposed by the carbonic acid of the air, and thus to become partially insoluble. When heated, they fuse, give out their water of crystallization, and, at a higher temperature, are decomposed; yielding acetic acid, acetone, carbonic acid, inflammable gas, and water: the residuum is a pyrophoric mixture of lead and charcoal. Acetate of lead is soluble in both water and alcohol. The aqueous solution feebly reddens litmus, though it communicates a green colour to the juice of violets. "A solution of the neutral acetate is partially decomposed by carbonic acid: a small quantity of carbonate of lead is precipitated, and a portion of acetic acid is set free, which protects the remaining solution from further change."[1]

FIG. 137.



Crystal of Acetate of Lead.

Characteristics.—When heated with sulphuric acid, the vapour of acetic acid is disengaged. Its solution is known to contain lead by the tests for this metal already mentioned (see *ante*, p. 726). If a small quantity of acetic acid be added to the solution, a current of carbonic acid occasions no precipitate. The ordinary acetate of the shops throws down a scanty white precipitate (*carbonate of lead*) with carbonic acid. When charred, it readily yields globules of metallic lead on the application of the blowpipe flame.

COMPOSITION.—The neutral acetate has the following composition:—

	Atoms.	*Eq. Wt.*	*Per Cent.*	*Berzelius.*
Oxide of Lead	1	112	58·95	58·71
Acetic Acid	1	51	26·84	26·97
Water	3	27	14·21	14·32
Crystallized Acetate of Lead	1	190	100·00	100·00

PURITY.—It should be readily and completely soluble in water. Sulphuric acid, or sulphuretted hydrogen in excess, being added to the solution to throw down the lead, the supernatant liquor should be completely volatilized by heat: any fixed residue is impurity.

Dissolved by distilled water. By carbonate of soda a white precipitate is thrown down from the solution, and by iodide of potassium a yellow one; by hydrosulphuric acid it is blackened. Sulphuric acid evolves acetic vapours. By heat it first fuses, and is afterwards reduced to metallic lead.—*Ph. L.*

Entirely soluble in distilled water acidulated with acetic acid: forty-eight grains thus dissolved are not entirely precipitated by a solution of thirty grains of phosphate of soda.—*Ph. Ed.*

PHYSIOLOGICAL EFFECTS. *a. On Vegetables.*—Marcet found the solution of acetate of lead injurious to plants; but Wiegmann declares it to be inert, and ascribes its inertness to the formation of an insoluble salt (carbonate) of lead by the carbonic acid of the roots of the plants.

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[1] Dumas, *Traité de Chim.* t. v. p. 173.

β. *On Animals.*—Orfila[1] found that in large doses the acetate of lead acted on dogs as an irritant, and caused vomiting, pain, and death. When the action was slower, and absorption took place, an affection of the nervous system was observed, marked by difficult progression, and, in some cases, convulsive movements. The mucous membrane lining the alimentary canal was found whitened (owing to the chemical influence of the poison), and, where the action was more prolonged, reddened. Injected into the veins, or applied to wounds, it affects the nervous system. Schloepfer[2] produced colica pictonum, paralysis, and convulsions in dogs, by the repeated use of small doses. Dr. A. T. Thomson[3] gave successively, one, two, three, and six drachms to a dog without any ill effect.

γ. *On Man.*—Applied to ulcers, mucous membranes, or other secreting surfaces, it acts as a desiccant and astringent. It reacts chemically on the albumen of the secretions and of the living tissues, and forms therewith compounds which are for the most part insoluble in water and acids.[4] Hence the difficulty with which this salt becomes absorbed. Some of its compounds with organic substances are, however, rendered soluble in water by acids (as the acetic, hydrochloric, and lactic). In large quantities, acetate of lead taken into the stomach acts as an irritant, and causes symptoms of inflammation of the stomach, viz. vomiting, burning in the gullet and stomach, and tenderness at the pit of the stomach; but these are usually accompanied with colica pictonum, and are not unfrequently followed by convulsions, coma, or local palsy.[5] Ten grains taken daily for seven days caused tightness of the breast, metallic taste, constriction of the throat, debility, sallow countenance, slow respiration and circulation, turgid and tender gums, ptyalism, tightness and numbness in the fingers and toes, no nausea, pains of the stomach and abdomen, bowels confined.[6] The observations of Dr. A. T. Thomson and others (Van Swieten,[7] Reynolds, Latham, Laidlaw, Daniell, Christison, &c.) have, however, shewn that injurious effects from the use of large doses are very rare. I have repeatedly given five grains three times a day for ten days, without inconvenience. This dose was taken for a fortnight.[8] The blue line on the gums was then very distinct, and the patient complained of griping pains in the bowels. A young man, suffering with hæmoptysis, and under my care in the London Hospital, took from July 21st to Aug. 27, 1842, 288 grs. of acetate of lead: at first in doses of 2 grs., then 3 grs., thrice daily. The leaden line on the gums was by no means well marked; at least I have seen it much better marked from a smaller quantity of lead. He experienced slight gripings. The hæmoptysis was most distinctly relieved by it. He took the lead in the form of pills in combination with opium.

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[1] *Toxicol. Gén.*

[2] Quoted by Dr. Christison, p. 507.

[3] *Lond. Med. Gaz.* x. 691.

[4] Dr. C. G. Mitscherlich, *Brit. Ann. of Med.* i. 204.

[5] Christison, *Treatise on Poisons*, 3d edit. p. 512.—In a recent case, an ounce of acetate of lead in solution caused, in a young girl, collapse and syncope, followed by vomiting and convulsions. Orfila detected lead in the urine (*Pharm. Trans.* No. vi. p. 119).

[6] Laidlaw, *Lond. Med. Repos.* N.S. vi. 292.

[7] *Commentaries*, vol. x. p. 236, Eng. edit. Van Swieten says colic was induced by the use of a drachm of lead in an emulsion every day for ten days.

[8] In the *Journ. de Chim. Méd.* (t. vi. 21e Série, p. 97) a case is related of death from this salt. The patient, a boy of 15 years of age, affected with a phthisical malady, took from a ¼ gr. to grs. ii. four times a day, until he had taken 130 grs. without any ill effect. A month after he was seized with colic, which was followed by paralysis and death.

Dr. Christison has given eighteen grains daily for eight or ten days without any unpleasant symptoms whatever, except once or twice slight colic.

During its employment the gums should be frequently examined, in order that the earliest appearance of the blue line, before referred to, may be detected. Whenever this salt gives rise to any obvious effects, they are those of the plumbeous preparations in general, and which have been already described. Its medicinal action, therefore, is sedative and astringent.

USES.—Acetate of lead is administered *internally* to diminish the diameter of the capillary vessels, and lessen circulation, secretion, and exhalation.

Thus, we employ it in profuse discharges from the mucous membranes; as from the lungs, alimentary canal, and even the urino-genital membrane. In the mild cholera, so common in this country towards the end of summer, I have found acetate of lead in combination with opium most efficacious where the chalk mixture failed. I have used this combination in a few cases of malignant cholera, and in one or two with apparent benefit. In colliquative diarrhœa and chronic dysentery it occasionally proves serviceable.[1] In phthisis it has been found beneficial, but only as a palliative; namely, to lessen the expectoration, check the night-sweats, or stop the harassing diarrhœa. Dr. Latham[2] speaks most favourably of the use of sugar of lead and opium in checking purulent or semi-purulent expectoration. I have repeatedly seen it diminish expectoration, but I have generally found it fail in relieving the night-sweats, though Fouquier supposed it to possess a specific power of checking them: they are more frequently benefited by diluted sulphuric acid.

In sanguineous exhalations from the mucous membranes, as epistaxis, hæmoptysis, and hæmatemesis, and in uterine hemorrhage, it is employed with the view of diminishing the calibre of the bleeding vessels, and thereby of stopping the discharge: and experience has fully established its utility.[3] It may be employed in both the active and passive states of hemorrhage. It is usually given in combination with opium.

In bronchitis, with profuse secretion, it proves exceedingly valuable.[4] It has been employed also as a remedy for mercurial salivation.[5] It has been applied for this affection in the form of gargle by Sommé.[6] Unless care be taken to wash the mouth carefully after its use, it is apt to blacken the teeth. On the same principles that we administer it to check excessive mucous discharges, it has been employed to lessen the secretion of pus in extensive abscesses attended with hectic fever.

There are some other cases in which experience has shewn acetate of lead is occasionally serviceable, but in which we see no necessary connection between its obvious effects on the body and its remedial powers; as in epilepsy, chorea, intermittents, &c.

As a *topical* remedy, we use acetate of lead as a sedative, astringent, and dessicant. An aqueous solution of it is applied to inflamed parts, or to secreting surfaces, to diminish profuse discharges. Thus, we use it in phlegmonous inflammation, in ophthalmia, in ulcers with profuse discharges, in gonorrhœa, and gleet. In the sloughing and ulceration of the cornea which attend purulent and pustular ophthalmia, its use should be prohibited, as it forms a white compound which is deposited on the ulcer, to which it adheres tenaciously, and in the healing becomes permanently and indelibly imbedded in the structure of the cornea. The appearance produced by this cause cannot be mistaken : its chalky impervious opacity distinguishes it from the pearly semi-transparent structure of even the densest opacity produced by common ulceration.[1] The white compound consists of oxide (acetate ?) of lead, animal matter, much carbonate of lead, traces of phosphate and chloride of the same metal.[2]

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[1] See Dr. Burke, *On the good Effects of a Mixture of Acetate of Lead and Tincture of Opium in the Dysentery which occurred in Dublin in* 1825, in the *Edinburgh Med. and Surg. Journal*, vol. xxvi. p. 56.

[2] *Med. Trans. Coll. Phys.* v. 341.

[3] Reynolds, *Trans. of Coll. Phys. London*, iii. 217; Davies, *Med. and Phys. Journ.* Jan. 1808, p. 8; also, Mitchell, *ibid.* p. 69; and Latham, *op. cit.*

[4] Henderson, *Lond. Med. Gaz.* May 8, 1840.

[5] Daniell, *Lond. Med. Repos.* N.S. vi. 308.

[6] *Archiv. Gén. de Méd.* i. 483.

A solution of acetate of lead may be employed as a disinfectant instead of the nitrate (see *ante*, p. 745).

ADMINISTRATION.—Acetate of lead may be administered internally in doses of one or two grains to eight or ten grains, repeated twice or thrice daily. Dr. A. T. Thomson advises its exhibition in diluted distilled vinegar, to prevent its change into carbonate, which renders it more apt to occasion colic. It is usually exhibited in the form of pill, frequently in combination with opium. Acetate of lead and opium react chemically on each other, and produce acetate of morphia and meconate, with a little sulphate of lead. Experience, however, has fully established the therapeutic value of the combination. Sulphuric acid (as in infusion of roses), sulphates (as of magnesia, and soda, and alum), phosphates and carbonates, should be prohibited. Sulphuric acid, the sulphates, and phosphates, render it inert: the carbonates facilitate the production of colica pictonum. Common (especially spring) water, which contains sulphates, carbonates, and chlorides, is incompatible with this salt. The liquor ammoniæ acetatis is incompatible with it on account of the carbonic acid usually diffused through this solution.

1. **CERATUM PLUMBI ACETATIS**, L. ; *Unguentum Plumbi Acetatis*, E. D. ; *Unguentum Saturninum ; Cerate of Sugar of Lead.* (Acetate of Lead, powdered, ʒij. ; White Wax, ℥ij. ; Olive Oil, f℥viij. *L.*—Simple Ointment, ℥xx. ; Acetate of Lead, in fine powder, ℥j. *E.*—Ointment of White Wax, lbiss. ; Acetate of Lead, ℥j. *D.* Mix.)—An excellent soothing application to irritable ulcers, painful excoriations, and blistered surfaces.

2. **PILULÆ PLUMBI OPIATÆ**, E. ; *Acetate of Lead and Opium Pills.* (Acetate of Lead, *six parts ;* Opium, *one part ;* Conserve of Red Roses, *about one part.* Beat them into a proper mass, which is to be divided into four-grain pills.—This pill may be made also with twice the quantity of opium).—Each pill contains three grains of acetate of lead, and half a grain of opium. I have before stated that, notwithstanding a mutual decomposition is effected between acetate of lead and opium, the resulting compound is a most efficacious one. The Edinburgh College, therefore, has done wisely in countenancing the combination, but the permission to vary the strength of the pill is highly objectionable. In hæmoptysis, profuse secretion of bronchial mucus, obstinate diarrhœa, and dysentery, its effects are most valuable. Dose, one to three grains.

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[1] Dr. Jacob, *Dublin Hospital Reports*, v. 369 ; also, Velpeau, *Lond. Med. Gaz.* Oct. 5, 1839.

[2] Dr. Apjohn, *op. cit.* p. 402.

2. Plumbi Diacetas.—Diacetate of Lead.

Formula $2PbO,\bar{A}$. *Equivalent Weight* 275.

HISTORY.—This compound was known to Basil Valentine in the fifteenth century.. It owes its reputation as a medicine principally to the praises bestowed on its solution by M. Goulard[1] in the latter end of the last century. He called it *extract of saturn* (*extractum saturni*). It is frequently termed *Goulard's extract.*

PREPARATION.—The following are the directions of the British Colleges for the preparation of the solution of diacetate of lead (*liquor plumbi diacetatis*, L.; *plumbi diacetatis solutio*, E.; *plumbi subacetatis liquor*, D.)

The *London College* orders, of Acetate of Lead, lbij. and ℥iij.; Oxide of Lead, rubbed to powder, lbj. and ℥iv.; Water, Ovj. Boil them for half an hour, frequently stirring, and when the liquor is cold, add of distilled Water as much as may be sufficient to measure with it six pints; lastly, strain [the solution].

The *Edinburgh College* employs, of Acetate of Lead, ℥vj. and ʒvj.; Litharge, in fine powder, ℥iv.; Water, Oiss.

The acetate of lead combines with an additional equivalent of oxide of lead to form the diacetate. This process yields an uniform product.

The *Dublin College* employs, of Litharge, *one part*; Distilled Vinegar, *twelve parts*. Boil together in a glass vessel until eleven parts of the fluid remain; then let the liquor rest, and when the impurities have subsided, let it be filtered.

In this process the acetic acid unites with the oxide of lead to form a subsalt. This method of preparation is objectionable, since the strength of the solution depends on the strength of the vinegar, which is subject to variation.

PROPERTIES.—It is a transparent and colourless liquid. Prepared according to the London Pharmacopœia, its specific gravity is 1·260: according to the Dublin Pharmacopœia, it is 1·118. Its taste is sweet and astringent. By evaporation it yields crystals of the diacetate of lead, which, according to Dr. Barker, are flat rhomboidal prisms with dihedral summits.

Characteristics.—The presence of lead and acetic acid in this solution may be known by the tests before mentioned for acetate of lead.

From the neutral acetate it is distinguished by the copious precipitate which it produces with carbonic acid, as well as with mucilage. Solution of the diacetate of lead forms a precipitate with most vegetable colouring matters.

COMPOSITION.—This liquid is an aqueous solution of the diacetate of lead. The solid hydrated diacetate having a crystalline aspect has, according to Dr. Thomson,[2] the following composition:—

	Atoms.	*Eq. Wt.*	*Per Cent.*
Oxide of Lead	2	224	61·37
Acetic Acid	1	51	13·97
Water	10	90	24·66
Solid Hydrated Diacetate of Lead	1	365	100·00

But, according to Schindler, the crystals dried at a temperature under 122°,

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[1] *A Treatise on the Effects and various Preparations of Lead, particularly of the Extract of Saturn, for different Chirurgical Disorders*, 2d edit. Lond. 1770.

[2] *First Principles of Chemistry*, vol. ii. p. 373.

F. consist of $2PbO,\bar{A},2HO$; but dried at 158°, F. their composition is $2PbO,\bar{A},HO$.

PURITY.—When this compound has been prepared with common vinegar, it has a brown colour. The properties of the pharmacopœial preparation are as follows:—

Its sp. gr. is 1·260. Its other properties are similar to those of the last preparation. —*Ph. Lond.*

A copious precipitate is gradually formed when the breath is propelled through it by means of a tube.—*Ph. Ed.*

PHYSIOLOGICAL EFFECTS.—Its effects are analogous to the acetate. Its chemical action on the living tissues depends on its affinity for albumen and fibrine. In a solution of albumen it occasions a white precipitate, composed of albumen and diacetate of lead. According to Lassaigne,[1] the precipitate caused in an albuminous liquor by the trisacetate of lead consists of *albumen* 71·67, and *trisacetate of lead* 28·33. This precipitate is soluble in an excess of the solution of the trisacetate, as well as in concentrated solutions of several salts (as acetate and nitrate of potash), and of caustic ammonia. Dr. A. T. Thomson[2] asserts, from his experiments on animals, that the diacetate has more tendency to cause colic than the neutral acetate, because it is more readily converted into carbonate of lead. It is employed in medicine as a local astringent and sedative. Paralysis is said to have resulted from its external use.

USES.—It is employed, when diluted, to promote the resolution of external inflammation, to check profuse discharges from suppurating, ulcerated, and mucous surfaces, and to alleviate local pains. Thus it is applied to parts affected with either phlegmonous or erysipelatous inflammation, to whitlows, to inflamed tendons, aponeuroses, or absorbent glands; in ophthalmia, to contusions, sprains, burns, wounds (whether incised or lacerated), to blistered surfaces, ulcers, abscesses, &c.

It is said to have proved successful, when administered internally, in hydrophobia.

The diacetate, as well as the acetate and nitrate, may be used for disinfecting purposes (see *ante*, p. 745).

ADMINISTRATION.—It is employed diluted with water, added to poultices, or mixed with fatty matters, and applied as an ointment.

1. LIQUOR PLUMBI DIACETATIS DILUTUS, *L.*; *Plumbi Subacetatis Liquor compositus*, D. (Solution of Diacetate of Lead, f℥iss.; Distilled Water, Oj.; Proof Spirit, ʒij. M.)—This preparation is an imitation of the *water of saturn*, or *vegeto-mineral water* of Goulard. It is commonly termed, in the shops, *goulard water*. It should be transparent and colourless; but when prepared with common water it is more or less milky, owing to the formation of carbonate, sulphate, and chloride of lead. It is also more or less turbid if it be made with distilled water which has been exposed to the air, and in consequence has absorbed carbonic acid. The small quantity of spirit employed can be of no service. The quantity of the solution of diacetate of lead employed in making Goulard water is much too small; it should be, at least, three times, and in some cases I have used six times as much. I have never seen any ill effects from its use, though it is said to have become absorbed in some cases. The same objection applies to the use of this compound as to that of the neutral acetate, in ulceration of the cornea (see *ante*, p. 750).

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[1] *Journ. de Chim. Méd.* t. vi. 2e Série, p. 299.

[2] *Lond. Med. Gaz.* vol. v. p. 538; vol. x. p. 693.

Goulard water is used as a cooling, sedative, and astringent wash in the cases already enumerated for the Goulard's extract. A poultice, composed of crumb of bread and Goulard water, is sometimes a very useful application to phlegmons, painful wounds, irritable ulcers, &c. &c.

2. **CERATUM PLUMBI COMPOSITUM**, *L.; Compound Cerate of Lead.* (Solution of Diacetate of Lead, f℥iij.; Wax, ℥iv.; Olive Oil, Oss.; Camphor, ʒss. Mix the melted Wax with eight fluidounces of the Oil; then remove them from the fire, and, when first they begin to thicken, gradually add the solution of Diacetate of Lead, and stir them constantly with a spatula until they cool; lastly, with these mix the camphor dissolved in the rest of the oil).—This is the *cerate of saturn* of M. Goulard, and is commonly called *Goulard's cerate.* If made with yellow wax it becomes white in blotches owing to the decoloration of the wax. If it be made with white wax it is more liable to become rancid. Does this depend on the spermaceti contained in the white wax of commerce? It is employed as a dressing to wounds and ulcers, for the purpose of allaying irritation and appeasing pain. With the same views it is also applied to excoriated surfaces, burns, scalds, blistered surfaces, and irritable cutaneous affections. Opium is sometimes advantageously combined with it.

3. **CERATUM SAPONIS**, *L.; Soap Cerate.*—This contains subacetate of lead. It has been before described (see *ante*, p. 569).

129. EMPLASTRUM PLUMBI.—PLASTER OF LEAD.

HISTORY.—This compound was known to the ancients: both Pliny[1] and Celsus[2] give a formula for a plaster used by the Roman surgeons, which is almost identical with that for the officinal plaster of lead. It is commonly sold in the shops as *diachylon* or *diachylum* (from διά, *through*, and χῦλος, *juice*).

PREPARATION.—The following are the directions of the British Colleges for its preparation:—

The *London College* orders of Oxide of Lead, rubbed to very fine powder, lbvj.; Olive Oil, *Cong.* j.; Water, Oij. Boil them together with a slow fire, constantly stirring, until the Oil and Oxide of Lead unite into the consistence of a plaster; but it will be proper to add a little boiling water, if nearly the whole of that which was used in the beginning should be evaporated before the end of the boiling.

The *Edinburgh College* orders of Litharge, in fine powder, ℥v.; Olive Oil, f℥xij.; Water, f℥iij. Mix them; boil and stir constantly till the oil and litharge unite, replacing the water if it evaporate too far.

The process of the *Dublin College* is similar to that of the London College.

Olive Oil is a compound of oleine (*oleate of glycerine*) and margarine (*margarate of glycerine*). When subjected to heat with litharge and some water, the oxide of lead combines with oleic and margaric acid, and sets free glycerine, which remains dissolved in the water. The mixture of oleate and margarate of lead constitutes *emplastrum plumbi* (see *ante*, p. 564). The water employed in this process serves two purposes:—it moderates the heat and facilitates the union of the acids with the oxide of lead.

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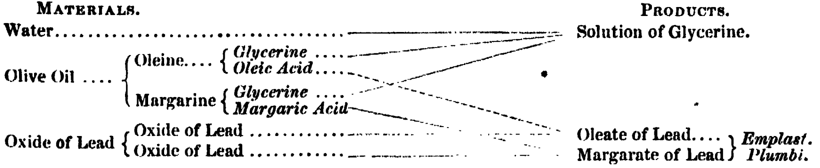
[1] *Hist. Nat.* xxxiv. 53.

[2] *De Medicina*, lib. v. cap. xix.



PROPERTIES.—It is met with in the shops in cylindrical rolls, of a greyish or yellowish-white colour, brittle when cold, but softening and ultimately fusing by heat. It is insoluble in water, and nearly so in alcohol. It has no taste, but a slight though peculiar odour.

Characteristics.—When heated it fuses, then decomposes, gives out inflammable gas, and leaves a carbonaceous residue, which, when heated in a close vessel, yields globules of lead. Ether dissolves oleate but not margarate of lead.

COMPOSITION.—Lead plaster consists of *oxide of lead, oleic acid,* and *margaric acid.* The proportions have not been precisely ascertained. The two compounds which oleic and margaric acids form with oxide of lead are probably basic salts.

EFFECTS AND USES.—This plaster is employed in surgery, on account of its adhesiveness and the mildness of its local action; for it rarely excites irritation. It is used to keep the edges of wounds together in persons with delicate skins. Spread on calico it forms a good *strapping* for giving support and causing pressure in ulcers of the leg,—a most successful mode of treating them, and for which we are indebted to Mr. Baynton.

In pharmacy it serves as a basis for various other plasters.

1. **EMPLASTRUM RESINÆ**, L.; *Emplastrum Resinosum*, E.; *Emplastrum Lithargyri cum Resinâ*, D.; *Resin Plaster.* (Resin, lbss. [℥j. *E.*] Lead Plaster, lbiij. [℥v. *E.*; lbiijss. *D.*] To the plaster of lead, melted with a slow fire, add the Resin, powdered, and mix.).—This is the common *adhesive plaster* (*emplastrum adhæsivum*), and is kept in the shops ready spread. It is employed to retain the lips of wounds in contact, as in cuts, surgical operations, &c. It is more adhesive than lead plaster, but at the same time somewhat more irritating, and it occasionally causes excoriation. It is employed as a *strapping* for dressing ulcers on Baynton's principles.

2. **EMPLASTRUM SAPONIS**, L. E. D.; *Soap Plaster.* This contains lead plaster (see *ante*, p. 570).

3. **UNGUENTUM PLUMBI COMPOSITUM**, L.; *Compound Ointment of Lead.* (Prepared Chalk, ℥viij.; Distilled Vinegar, f℥vj.; Plaster of Lead, lbiij.; Olive Oil, Oj. Mix the chalk with the vinegar; and, when the effervescence has ceased, add gradually the solution to the plaster and oil melted with a slow fire, and stir constantly until they are cooled).—By the action of the acetic acid on the chalk, an acetate of lime is procured, and carbonic acid

evolved, and the acetate of lime is then mixed with lead plaster and oil. This compound is an imitation of *Kirkland's neutral cerate,* which is used as a dressing to indolent ulcers. It is employed by Mr. Higginbottom,[1] under the name of *neutral ointment,* as a defence for ulcers after the application of nitrate of silver.

130. Plumbi Saccharas.—Saccharate of Lead.

Formula PbO,$\overline{\text{Sac}}$. *Equivalent Weight* 208.

By the action of nitric acid on sugar, an acid has been obtained which is known by the various names of *oxalhydric, hydro-oxalic,* and *saccharic* acid. The formula for the anhydrous acid, according to the analysis of Heintz,[2] is $C^6H^4O^7 = \overline{\text{Sac}}$. Thaulow had previously given, for the hydrated acid, the formula $C^{12}H^5O^{11} + 5HO$.

Saccharate of lead was first used in medicine by Dr. S. Elliott Hoskins.[3] This salt is best obtained by saturating an aqueous solution of saccharic acid with freshly precipitated and moist carbonate of lead, added in small successive portions: the first generally dissolve, but afterwards the saccharate falls in proportion as saturation ensues, in the form of a white powder, very sparingly soluble in boiling water.

Saccharic acid exerts no greater action on phosphatic concretions than malic acid; and saccharate of lead is inert; but the acid saccharate of lead is an active decomponent of phosphatic calculi, though mild in its action on the living tissues.

Dr. Hoskins prepared, what he calls *nitro-saccharate of lead,* by dissolving a portion of pulverized saccharate of lead in a sufficient quantity of cold dilute nitric acid (one acid to nineteen water). The solution was filtered and gradually evaporated, by which amber-coloured crystals in the form of regular hexagonal plates or prisms were obtained. These he calls the nitro-saccharate of lead.

A solution of nitro-saccharate of lead was prepared by moistening one grain of nitro-saccharate of lead with five drops of pure saccharic acid, and dissolving in a fluidounce of distilled water. The solution was bland without any astringency, though it possessed a slight acid reaction. It acted rapidly on phosphatic calculi; but was so mild in its influence on the urethral and conjunctival membranes as to be tolerated with perfect impunity. Injected into the bladder of sheep daily for several weeks, it excited no untoward symptoms. It was thrown daily, or every second day, into the bladder of an old gentleman who had long suffered from vesical affection, accompanied with alkaline urine, phosphatic sediment, and copious formation of ropy mucus. It was retained in the bladder for fifty minutes. The patient was much benefited by the practice.

In two cases in which calculi existed in the bladder it was injected without any injurious effect, and in one of the cases with positive comfort.

These experiments show that the solution, which possesses active decomposing powers on phosphatic calculi out of the body, is neither irritating nor injurious when introduced under proper restrictions into the bladder. Farther experiments, however, demonstrative of its therapeutic value, are required.

131. Plumbi Tannas.—Tannate of Lead.

Plumbum scytodepsicum.[4]—Pure tannate of lead is obtained by adding tannic acid to a solution of acetate of lead: the precipitate is to be collected on a filter, and dried.

Tannate of lead has been recommended by Autenrieth[5] in cases of *paratrimma decubitum,* or bed sores.

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[1] *Essay on the Use of Nitrate of Silver,* 2d edit. p. 119.

[2] *Chem. Gaz.* vol. ii. p. 255, 1844; also, Brande's *Manual of Chemistry,* vol. ii. p. 1315, 1848.

[3] *Philosophical Transactions* for 1843, p. 7.

[4] *Scytodepsicus,* σκυτοδεψικός, *belonging to curriers;* from σκῦτος, *a hide,* especially *a tanned hide,* and δέφω, *to make supple: acidum scytodepsicum,* tannic acid.

[5] *Journ. de Chimie Méd.* Mars 1837; *British Annals of Medicine,* June 2, 1837.

The ***cataplasma ad decubitum***, Ph. Boruss., or the ***unguentum ad decubitum Autenriethi***, is thus prepared:—Boil ℥ij. of bruised oak bark in a sufficient quantity of common water to yield ℥viij. of decoction. To the strained decoction add ℥ij. of the solution of diacetate of lead. The precipitate collected by a filter, weighs about three ounces. Add to it while moist ʒij. of rectified spirit. It is to be used while moist, and of the consistence of a thick liniment.

In sloughing bed sores Dr. Tott[1] used with success an ointment (*unguentum plumbi tannatis*) composed of two drachms of the dried tannate of lead, and one ounce of rose ointment.

C. Simon employed the tannate either as ointment or as a dusting powder in chronic ulcers of the feet; and Fontanelli used an ointment composed of one part tannate and two parts rose ointment in white swelling.[2]

ORDER XXVII. IRON AND ITS COMPOUNDS.

132. FERRUM.—IRON.

Symbol Fe. *Equivalent Weight* 28.

HISTORY.—This metal, called by the alchymists *Mars*, ♂, was known in the most ancient times. Moses,[3] who frequently mentions it, represents it as being known to the antediluvian patriarchs. It was employed medicinally at a very early period, namely, above 3200 years ago. Indeed, it appears to have been the first mineral used internally; and a curious anecdote is given of its introduction into medicine. Melampus (a shepherd supposed to possess supernatural powers) being applied to by Iphicles, son of Philacus, for a remedy against impotence, slaughtered two bulls, the intestines of which he cut to pieces, in order to attract birds to an augury. Among the animals which came to the feast was a vulture, from whom Melampus pretended to learn that his patient, when a boy, had stuck a knife, wet with the blood of some rams, into a consecrated chesnut tree, and that the bark had subsequently enveloped it. The vulture also indicated the remedy, namely, to procure the knife, scrape off the rust, and drink it in wine, for the space of ten days, by which time Iphicles would be lusty, and capable of begetting children. The advice thus given by Melampus is said to have been followed by the young prince with the most perfect success![4]

NATURAL HISTORY.—Iron is met with in both kingdoms of nature.

α. IN THE INORGANIZED KINGDOM.—Few minerals are free from iron. It is found in the metallic state (*native iron*, meteoric and terrestrial), in combination with oxygen (*hæmatite*, *micaceous iron*, *brown iron stone*, and *magnetic iron ore*), with sulphur (*iron pyrites*, and *magnetic pyrites*), with chlorine (in the mineral called *pyrosmalite*), and with oxygen and an acid (*carbonate*, *phosphate*, *sulphate*, *arseniate*, *tungstate*, *tantalate*, *tantalite*, *titaniate*, *chromite*, *oxalate*, and *silicate*). It is the colouring principle of many minerals. Its existence in mineral waters has been already noticed (see *ante*, p. 296).

β. IN THE ORGANIZED KINGDOM.—It occurs in the ashes of most plants, and in the blood and some other parts of animals.

EXTRACTION.—In Sweden, iron is extracted from *magnetic iron ore* (FeO,Fe^2O^3) and *micaceous iron* (Fe^2O^3); in England, principally from *clay iron ore* (an impure carbonate of iron, FeO,CO^2).

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[1] Dierbach, *Die neuesten Entdeckungen in der Mat. Med.* Bd. ii. S. 1227, 1843.
[2] *Ibid.* Bd. ii. S. 1228 and 1229.
[3] *Genesis*, iv. 22; *Deuteronomy*, iv. 20, viii. 9.
[4] Le Clerc, *Hist. de la Médecine.*

Clay iron ore (technically called *mine*) is *roasted* on large heaps of coal, by which it loses carbonic acid, water, and sulphur. It is then *smelted* with a flux (in South Wales this is limestone; in the forest of Dean, clay) and coke. The flux and the earthy particles of the ore run down into a *slag* (chiefly composed of silica in combination with lime, alumina, magnesia, and the protoxides of manganese and iron). The carbonate of iron is deprived of its oxygen by the carbon of the coke, and the iron, in combination with carbon, is melted and run into moulds, where it cools and forms *sow-metal*, *pig-metal*, or *pig-iron*, or *cast iron* (*ferrum fusum*).

Cast iron is an impure *carburet* or *subcarburet of iron*, which may be represented by the formula Fe^4C. Besides this subcarburet of iron, it contains usually *silicon*, *phosphorus*, and *manganese*. There are three kinds of cast iron, viz. *black*, *grey* or *mottled*, and *white*.

To deprive iron of the substances with which it is combined in cast iron, the latter is successively submitted to the processes of *refining*, *puddling*, and *welding*, by which it is converted into *wrought iron* (*ferrum cusum*). The essential objects of these processes are to burn off the carbon of the cast iron and to oxidize the silicon, by which silicic acid is formed: this unites with oxide of iron.[1]

PROPERTIES.—The primary form of the crystals of native iron is the regular octohedron. Pure iron has a whitish-grey colour, or, according to Berzelius, is almost silver-white. When polished, it has much brilliancy: its taste is peculiar and styptic; when rubbed, it becomes odorous. Its ductility and tenacity are great, its malleability comparatively small. Its sp. gr. is 7·788, but diminishes by rolling or drawing.

Iron is magnetic (see *ante*, p. 57). Pure iron, commonly called *soft iron*, when subject to the influence of a magnet, becomes magnetic and capable of attracting another piece of iron; but immediately the influence of the magnet is withdrawn, it loses its magnetic property. The carburets of iron, as steel and cast iron, retain, on the other hand, their magnetic properties under the same circumstances, and become *permanent* magnets. When heated to redness, iron ceases to be magnetic.

When iron is exposed to moist air, it becomes covered by a coating of hydrated oxide of iron, called *rust of iron*. When a spot of this is formed, the metal is rapidly oxidated, because there are formed the elements of a voltaic pile, of which the rust is the negative pole, and the metallic iron the positive pole. The oxidation is accelerated by the presence of carbonic acid in the air. Rust usually contains ammonia. When iron is coated with zinc to preserve it from rusting, it is said to be *galvanized*. Iron and zinc are two elements of a voltaic pile, of which the iron is negative to the zinc.

Considered with respect to its action on acids, iron is said to be either *active* or *passive*. In general, nitric acid, of sp. gr. 1·35, acts powerfully on iron, and forms a solution of the nitrate of iron. Iron which undergoes this change is said to be *active*. But various circumstances (such as immersing the metal in fuming nitric acid, &c. &c.) are capable of throwing the iron into a *passive* condition, in which it resists the action of acids.

It requires a very intense heat (=3300°, F., according to Daniell) to fuse it, and in the softened state, previous to melting, it is capable of being *welded*.

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[1] For further details respecting the manufacture of iron, see the article *Manufacture of Iron*, in the *Library of Useful Knowledge*; also, *Treatise on Iron and Steel*, in *Lardner's Cyclopædia*; and Brande's *Manual of Chemistry*.

Characteristics.—Iron readily dissolves in diluted sulphuric acid, with the evolution of hydrogen gas. $Fe + HO,SO^3 = FeO,SO^3 + H$.

The solution of protosulphate of iron readily attracts oxygen from the air, by which a portion of protoxide (FeO) is converted into sesquioxide of iron (Fe^2O^3). Hydrosulphuret of ammonia ($NH^3,2HS$) occasions a black precipitate (FeS) when added to the solution. Caustic potash or ammonia produces a whitish precipitate (FeO,HO), which becomes greenish, and ultimately, by exposure to the air, reddish-brown ($Fe^2O^3,3HO$). Ferrocyanide of potassium causes a white, or bluish-white precipitate, which, by exposure to the air, ultimately becomes blue. Ferridcyanide of potassium occasions a dark blue precipitate, called Turnbull's blue. Binoxide of nitrogen communicates a greenish-brown colour to a solution of protosulphate of iron (see *ante*, p. 408).

By boiling the solution of the protosulphate with a little nitric acid, we obtain in solution persulphate of iron. This yields, with ferrocyanide of potassium, a blue precipitate (Prussian blue); with ferridcyanide of potassium, a deep green solution, but no precipitate; with sulphocyanide of potassium, a red colour, owing to the formation of a soluble persulphocyanide of iron ($2Fe,3CyS^2$); with meconic acid, a red coloured liquid ($Fe^2O^3,\overline{Mec}$); with gallic or tannic acid, a purple or bluish-black precipitate; with succinate of ammonia, a light brown precipitate ($Fe^2O^3,2\overline{Suc}$); with benzoate of ammonia a yellowish-brown precipitate ($Fe^2O^3,3\overline{Bz}$).

PHYSIOLOGICAL EFFECTS. *a.* **Of Metallic Iron.**—Iron is probably inert, or only acts mechanically (see *ante*, p. 189), so long as it retains its metallic form; but it readily oxidizes in the alimentary canal, and thereby acquires medicinal power (see *ante*, p. 191). As acids promote this chemical change, acid wines and fruits assist in rendering the metal active, while alkalies and their carbonates have an opposite effect. The oxidizement of the iron is attended with the evolution of hydrogen gas, which gives rise to unpleasant eructations. If sulphur be taken along with iron, hydrosulphuric acid is developed. Like the ferruginous preparations generally, the internal employment of iron causes blackening of the stools, owing to the formation of the hydrated sulphuret of iron (see *ante*, p. 189). The nature of the effects produced by oxide of iron formed in the alimentary canal will be best examined hereafter under the head of ferruginous preparations. I may, however, remark here, that it is one of the few metals which by oxidizement is not rendered more or less poisonous.

β. **Of the Ferruginous Compounds.** *aa.* *On Vegetables.*—Most of the compounds of iron do not appear to be hurtful to plants; at least, this is the case with the oxides.[1] The sulphate, however, is injurious to vegetation.

ββ. *On Animals.*—The effects of the ferruginous compounds on animals generally are similar to those on man. It is stated that in animals to whom iron has been given for a considerable time, the spleen has been found smaller, harder, and denser (see *ante*, p. 193). The liver is also said to have been affected in a similar manner, though in a somewhat slighter degree.

γγ. *On Man.*—The *local* effects of the sulphate, nitrate, and sesquichloride of iron are those of caustics and irritants, and these preparations accordingly rank amongst poisons.

Most of the ferruginous preparations are astringent; that is, they constringe the parts with which they are in contact, and thereby diminish secretions and check sanguineous discharges. Thus, when swallowed, they repress the secretions and exhalation of the gastro-intestinal membrane, and thereby render the alvine evacuations more solid, and even occasion costiveness. The sulphate, nitrate, and sesquichloride of iron, are the most powerful of the ferruginous astringents. Administered in large quantities, or when the alimentary canal is in an irritable condition, all the compounds of iron are liable to excite heat, weight, and uneasiness at the præcordia, nausea, and even vomiting, and sometimes purging. The oxides and the carbonate of iron are very mild topical agents.

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[1] De Candolle, *Phys. Vég.* 1837.

Before the chalybeates can produce constitutional effects they must become absorbed. Under their use the blood frequently acquires a more scarlet colour, owing to an increase in the number of its colouring particles. Tiedemann and Gmelin[1] have detected it in the serum of the blood of the portal and mesenteric veins of horses and dogs, to whom they administered either the sulphate or chloride. Occasionally, too, iron has been found in the urine. Moreover, Menghini[2] asserts, that the quantity of iron in the blood of dogs may be increased by feeding them on substances mixed with this metal. Lastly, iron has been detected in the milk of animals to whom the oxide had been administered.[3]

The remote constitutional effects of chalybeates have been already described (see *ante*, pp. 189-191). These preparations I have ventured to call *hæmatinics*, on account of their influence in augmenting the amount of hæmatin in the blood.

Unlike the antispasmodic spanæmics (arsenic, silver, copper, bismuth, and zinc) before noticed (see *ante*, p. 185), as well as lead and mercury, the chalybeates do not excite cramps, convulsions, paralysis, or narcotism, when administered in large doses or for a long period.

USES.—The general indications and contra-indications for the use of chalybeates, as well as a notice of the principal maladies in which they are employed, have been already given (see *ante*, pp. 191-194).

1. **FERRI FILUM**, Ph. Edin.; *Ferri Fila*, Ph. D.; *Iron Wire*.—This is used for pharmaceutical purposes only; as for the preparation of *iodide of iron, sulphate of iron, rust of iron*, and *tartarized iron*.

2. **FERRI RAMENTA**, Ph. Lond.; *Ferri Limatura*, Ph. Edinb.; *Ferri Scobs*, Ph. Dub.; *Iron Filings*.—These are generally procured from the workshop of the smith, and are usually impure, being mixed with the filings of other metals, &c. The magnet is commonly employed to separate the ferruginous from other particles, but it does this imperfectly, as various impurities cling to the iron particles. The only way to procure them pure is by filing a piece of pure iron with a clean file.

Iron filings are employed in pharmacy for the preparation of *sulphuret of iron, sulphate of iron*, and *iodide of iron*.

In medicine they have been administered as an antidote in poisoning by the soluble salts of copper and mercury (see *ante*, p. 161). The iron reduces them to the metallic state. The following formula explains the action of iron on a solution of sulphate of copper:—$CuO,SO^3 + Fe = Cu + FeO,SO^3$.

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[1] *Vers. üb. d. Wege auf welch. Subst. aus d. Magen u. Darmk.*

[2] Menghini, *De Ferrearum particularum progressu ad sanguinem*, in the *Comment. Acad. Bonon.* t. ii. pt. iii. p. 475. (A notice of these is given by Bayle in his *Bibliothèque de Thérapeutique*, t. iv. Paris, 1837).

[3] Chevallier and O. Henry *Journ. de Chim. Méd.* sér. 2e, tome v. p. 200, 1839.

Iron filings are accounted anthelmintic, especially for the small thread worm (see *ante*, p. 229). They have been used also as an astringent application, to repress fetid secretion of the feet. They have likewise been employed to produce the constitutional effects of the chalybeates; but for this purpose they are inferior to most of the ferruginous compounds (see *ante*, p. 191).

The dose of iron filings is from ten to thirty grains, given in the form of an electuary made with treacle, honey, or some other thick substance.

133. FERRI OXYDUM NIGRUM.—BLACK OXIDE OF IRON.

Formula $Fe^3O^4 = FeO,Fe^2O^3$. *Equivalent Weight* 116.

HISTORY.—It was first employed as a medicine by Lemery in 1735. It is the *martial ethiops* (*æthiops martialis*) of some writers, and the *oxydum ferroso-ferricum* of Berzelius. It is sometimes termed the *magnetic oxide of iron*: and sometimes the *deutoxide of iron*.

NATURAL HISTORY.—It occurs in the mineral kingdom under the name of *magnetic iron ore*, the massive form of which is called *native loadstone*. It is found in Cornwall, Devonshire, Sweden, &c.

PREPARATION.—Directions for its preparation are given by both the Edinburgh and Dublin Colleges.

1. The *Edinburgh College* orders it to be prepared as follows:—

Take of Sulphate of Iron, ℥vj.; Sulphuric Acid (commercial) fʒij. and f℈ij.; Pure Nitric Acid, fʒiv.; Stronger Aqua Ammoniæ, f℥ivss.; Boiling Water, Oiij. Dissolve half the sulphate in half the boiling water, and add the sulphuric acid; boil; add the nitric acid by degrees, boiling the liquid after each addition briskly for a few minutes. Dissolve the rest of the sulphate in the rest of the boiling water; mix thoroughly the two solutions; and immediately add the ammonia in a full stream, stirring the mixture at the same time briskly. Collect the black powder on a calico-filter; wash it with water till the water is scarcely precipitated by solution of nitrate of baryta; and dry it at a temperature not exceeding 180°.

The object of the first part of this process is to convert the sulphate of the protoxide of iron into the sulphate of the sesquioxide. This is effected by adding nitric acid to the boiling solution. The acid gives oxygen to the protoxide, while binoxide of nitrogen gas escapes. The additional quantity of sulphuric acid is required to enable the salt to preserve its neutrality, and prevent the deposition of a basic sulphate of the sesquioxide. If, however, the sulphate of iron directed to be used be a pure protosulphate, the additional quantity of sulphuric acid ordered by the Edinburgh College is not sufficient for the purpose. On the addition of ammonia to the mixed solution of the protosulphate and sesquisulphate of iron, a compound of the hydrated protoxide and sesquioxide of iron is precipitated. This is to be washed with water until all traces of sulphuric acid are got rid of. When dried at 180° it constitutes the *ferri oxidum nigrum* of the Edinburgh Pharmacopœia.

2. The Dublin College directs it to be prepared from the scales of oxide of iron (*ferri oxydi squamæ*) as follows:—

> Let the scales of Oxide of Iron which are to be found at the smiths' anvils, be washed with water; and when dried, let them be detached from impurities by application of a magnet. Then let them be reduced to powder, of which let the most subtile parts be detached, according to the mode directed for the preparation of chalk.

Scales of iron are a mixture or combination of protoxide and sesquioxide; but they are not uniform in constitution. The process of the Dublin Pharmacopœia has the advantage of cheapness.

There are several other methods of procuring this compound. In the Paris Codex it is directed to be prepared by covering iron with water and exposing the mixture to the air: then, by elutriation, separating the black powder.

PROPERTIES.—*Magnetic iron ore*, FeO,Fe^2O^3, occurs earthy, compact, lamelliform, and crystallized in the form of the regular octohedron.

Scales of oxide of iron (*ferri oxydi squamæ*, Ph. Dub.) vary somewhat in their properties and composition. The *inner scales*, $6FeO,Fe^2O^3$, are blackish grey, porous, and brittle. The *outer scales*, $4FeO,Fe^2O^3$, are redder.

Hydrated black oxide of iron (*ferri oxydum nigrum*, Ph. Ed.) contains about seven per cent. of water. It is a greyish-black powder, with a velvety appearance, and is strongly magnetic. It dissolves in hydrochloric acid without effervescence. According to the Edinburgh Pharmacopœia its properties are as follows:—

> "Dark grayish-black: strongly attracted by the magnet: heat expels water from it: muriatic acid dissolves it entirely; and ammonia precipitates a black powder from this solution."—*Ph. Ed.*

COMPOSITION.—*Magnetic iron ore* has the following composition:—

	Atoms.	*Eq. Wt.*	*Per Cent.*	*Fuchs.*
Iron	3	84	72·414	71·91
Oxygen	4	32	27·586	28·09
Magnetic Iron Ore	1	116	100·000	100·00

or

	Atoms.	*Eq. Wt.*	*Fuchs.*
Protoxide	1	36	30·88
Sesquioxide	1	80	68·40
	1	116	99·28

Scales of oxide of iron, according to Mosander, have the following composition:—

	Outer Layer.		*Inner Layer.*	
	Atoms.	*Eq. Wt.*	*Atoms.*	*Eq. Wt.*
Protoxide of Iron	4	144	6	216
Sesquioxide of Iron	1	80	1	80
Scales of Iron	1	224	1	296

Hydrated black oxide of iron (*ferri oxydum nigrum*, Ph. Ed.), called by Wöhler[1] *æthiops martialis hydratum*, has the following composition:—

	Atoms.	*Eq. Wt.*	*Per Ct.*
Iron	3	84	67·2
Oxygen	4	32	25·6
Water	1	9	7·2
Hydrated Black Oxide of Iron	1	125	100·0

or

	Atoms.	*Eq. Wt.*	*Per Ct.*
Protoxide of Iron	1	36	28·8
Sesquioxide of Iron	1	80	64·0
Water	1	9	7·2
	1	125	100·0

PURITY.—Black oxide of iron should be readily soluble in hydrochloric acid, without effervescence; by which the absence of metallic iron is shown.

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[1] *Ann. d. Pharm.* Bd. xx. S. 56 (*Jahrbuch d. Pharmacie*, Bd. xxxvii. 1837).

PHYSIOLOGICAL EFFECTS AND USES.—These are similar to those of the chalybeates in general, and which have been already described. It does not produce local irritation. It is a more valuable preparation than the sesquioxide, in consequence of being more readily soluble in the fluids of the stomach.

ADMINISTRATION.—Dose from grs. v. to ℈j. or more, twice or thrice daily.

134. FERRI SESQUIOXYDUM.—SESQUIOXIDE OF IRON.

Formula Fe^2O^3. *Equivalent Weight* 80.

HISTORY.—Geber[1] was acquainted with this substance, which he calls *crocus martis*. It was probably known long before his time. It is the *red oxide of iron* (*ferri oxydum rubrum*), or *peroxide of iron*, of some writers.

NATURAL HISTORY.—It is found native in the crystallized state (*specular iron, micaceous iron*, or *iron glance*) and in globular and stalactitic masses (*red hæmatite*): the finest specimens of the first occur in the Isle of Elba; the second is found near Ulverstone, in Lancashire, and in Saxony. *Red ochre* is sesquioxide of iron in a soft and earthy form. *Reddle*, or *red chalk*, is an argillaceous substance, which owes its colour to sesquioxide of iron.

Hydrated sesquioxide of iron is also found native, and will be noticed subsequently.

PREPARATION.—There are several modes of preparing this compound:—

1. By precipitation from Sulphate of Iron.

The *London College* orders of Sulphate of Iron, lbiv.; Carbonate of Soda, lbiv. and ℥ij; Water, boiling, *Cong.* vj. Dissolve the Sulphate of Iron and Carbonate of Soda, separately, in three gallons of Water; then mix the liquors together, and set them by, that the powder may subside. Lastly, the supernatant liquor being poured off, wash what is precipitated with water, and dry it.

The *Edinburgh College* employs of Sulphate of Iron, ℥iv.; Carbonate of Soda, ℥v.; Boiling Water, Oss.; Cold Water, Oiijss. Dissolve the sulphate in the boiling water, add the cold water, and then the carbonate of soda, previously dissolved in about thrice its weight of water. Collect the precipitate on a calico filter; wash it with water till the water is but little affected with solution of nitrate of baryta, and dry it in the hot-air press, or over the vapour bath.

The *Dublin College* orders it [*Ferri Carbonas*, D.] to be prepared with *twenty-five parts* of sulphate of iron, *twenty-six parts* of carbonate of soda, and *eight hundred parts* of water.

In this process one equivalent of sulphate of iron is decomposed by one equivalent of carbonate of soda; and the products of their mutual reaction are one equivalent of carbonate of the protoxide of iron, which is precipitated, and one equivalent of sulphate of soda, which remains in solution. $FeO,SO^3 + NaO,CO^2 = FeO,CO^2 + NaO,SO^3$.

MATERIALS.		COMPOSITION.		PRODUCTS.	
1 eq. Carbonate Soda	53	1 *eq. Soda*	31	1 eq. Sulphate of Soda	71
		1 *eq. Carbonic Acid* ..	22		
1 eq. Sulphate Iron..	76	1 *eq. Sulphuric Acid*..	40		
		1 *eq. Oxide of Iron* ...	36	1 eq. Carbonate of Iron ...	58
	129		129		129

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[1] *Invention of Verity*, p. 280.

By exposure to the air during the washing and drying, the carbonate of the protoxide of iron is decomposed, the oxygen of the air combines with the protoxide, and thereby converts it into sesquioxide, while carbonic acid is disengaged. $2(FeO,CO^2)+O=Fe^2O^3+CO^2$.

When prepared according to the above directions, its colour is reddish chocolate brown, and it usually contains a small portion of undecomposed carbonate of the protoxide of iron. Manufacturers, however, usually calcine it in an iron pot, by which it acquires a brownish-red colour and is more saleable.

Sesquioxide of iron, as thus procured, is frequently termed *carbonate* or *subcarbonate of iron* (*ferri carbonas*, D.), or *precipitated carbonate of iron* (*ferri carbonas præcipitatus*).

2. **By calcining Sulphate of Iron.**

The *Dublin College* orders it [*Ferri Oxydum Rubrum*, D.] to be prepared as follows:—Let sulphate of iron be exposed to heat until the water of crystallization shall be expelled; then, with a strong fire, let it be roasted so long as acid vapour rises. Let the red oxide be washed until the washings, when examined by litmus, shall appear free from acid. Lastly, let it be dried on bibulous paper.

In this process the water and sulphuric acid of the crystallized sulphate of iron are evolved. The iron is peroxidized at the expense of a portion of the sulphuric acid, while some sulphurous acid is developed.

Sesquioxide of iron, prepared by this process, is known in commerce as *colcothar*, *caput mortuum vitrioli*, *trip*, *brown-red*, *rouge*, and *crocus*. The scarlet parts are called *rouge;* the red, purple, or whitish parts, which have been exposed to the strongest heat, are termed *crocus*. *Purple brown* is the name given to the sesquioxide which has been exposed to an intense white heat. *Venetian red* is essentially sesquioxide of iron obtained by calcining sulphate of iron. It is, however, usually adulterated (with *reddle* ?) to suit the prices of the market. The powder sold in the shops as *bole armeniack* is a mixture of pipe clay and Venetian red (see *ante*, p. 621).

3. **From Rust of Iron.**

The *Dublin College* orders Rust of Iron (*Rubigo Ferri*, D.) to be thus prepared:—Take of iron wire any required quantity. Moisten it with water, and expose it to the air until it is corroded into rust. Then let it be rubbed in an iron mortar; and, by the affusion of water, let the most subtile powder be washed off and dried.

It is directed to be prepared from iron wire on account of its purity. Rust of iron is usually reduced to an impalpable powder by levigation and elutriation, and is then made up into small conical loaves like prepared chalk (*prepared rust of iron*).

PROPERTIES.—The primary form of the crystals of native sesquioxide of iron is the rhombohedron.

The artificial sesquioxide of the shops is a brownish-red powder: when it has been exposed to an intense heat, it has a purplish tint. It is odourless, insoluble in water, and not magnetic. Prepared according to the London Pharmacopœia, it has a styptic taste: when calcined, it is tasteless. When quite free from carbonate of iron, it dissolves in hydrochloric acid without effervescence.

Characteristics.—Its hydrochloric solution affords a deep blue precipitate with the ferrocyanide of potassium, a purplish-black precipitate with tincture of nutgalls, a brownish-red precipitate with the alkalies, and a red colour with sulphocyanic or meconic acid.

COMPOSITION.—Sesquioxide of iron has the following composition:—

	Atoms.	*Eq. Wt.*	*Per Cent.*	*Gay-Lussac.*	*Berzelius.*
Iron	2	56	70	70·27	69·22
Oxygen	3	24	30	29·73	30·78
Sesquioxide of Iron	1	80	100	100·00	100·00

PURITY.—If it should contain copper, its hydrochloric solution will deposit this metal on a bright rod of iron. After the sesquioxide has been thrown down by ammonia from the hydrochloric solution, the supernatant liquor should give no indications of containing any other metal in solution, and chloride of barium ought not to occasion any precipitate. Orfila[1] obtained traces of arsenic in the sesquioxide of commerce by boiling this substance for five hours with pure sulphuric acid, and placing the solution in Marsh's apparatus.

Dissolved totally by dilute hydrochloric acid, with very slight effervescence, and it is precipitated by ammonia.—*Ph. Lond.*

" Entirely soluble in muriatic acid, aided by gentle heat."—*Ph. Ed.*

PHYSIOLOGICAL EFFECTS.—It is termed alterative, tonic, and emmenagogue. Its obvious effects on the body are very slight. It produces blackness of the stools, and in large doses occasions nausea, a sensation of weight at the pit of the stomach, and sometimes dyspeptic symptoms. It possesses very little astringency. The constitutional effects arising from the continued use of it are those produced by the ferruginous compounds generally, and which have been before described.

USES.—It may be employed in any of the before-mentioned cases in which the ferruginous tonics are indicated.

It has been strongly recommended by Mr. Benjamin Hutchinson[2] as a remedy for neuralgia, and in some cases it gives complete, in others partial, relief. But in many instances no benefit whatever is obtained from its use, and in one case in which I prescribed it the patient fancied it increased her sufferings. Mr. Carmichael, as already stated (see *ante*, p. 193), has recommended it as a remedy for cancerous diseases.

ADMINISTRATION.—The usual dose, as a tonic and emmenagogue, is from grs. x. to ʒss. In tic douloureux it is given in much larger quantities, as from ʒss. to ʒiij. or ʒiv. It may be administered in the form of an electuary. To enable it to sit easily on the stomach, it may be combined with aromatics.

EMPLASTRUM FERRI, E.; *Emplastrum Thuris*, D.; *Emplastrum Roborans; Iron, Frankincense*, or *Strengthening Plaster*. (Litharge Plaster, ℥iij.; Resin, ʒvj.; Olive Oil, fʒiijss.; Bees'-wax, ʒiij.; Red Oxide of Iron, ℥j. Triturate the oxide of iron with the oil, and add the mixture to the other articles previously liquefied by gentle heat. Mix the whole thoroughly, *Ed.*—Litharge Plaster, lbij.; Frankincense (*Thus*), lbss.; Red Oxide of Iron, ℥iij. M., *D.*)—Spread on leather, it is employed as a mechanical support and slight stimulant in muscular relaxation, lumbago, weakness of the joints, &c.

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[1] *Journal de Chimie Méd.* t. vi. 2nde Série, p. 646.

[2] *Cases of Tic Douloureux successfully treated*, 1820.

135. FERRI SESQUIOXYDUM HYDRATUM.— HYDRATED SESQUIOXIDE OF IRON.

HISTORY.—In the year 1834, this preparation was proposed by Drs. Bunsen and Berthold as an antidote for poisoning by arsenious acid.[1]

NATURAL HISTORY.—The hydrated sesquioxide of iron (*brown iron stone*) is met with in Scotland, and at Shotover Hill, Oxfordshire.

PREPARATION.—The Edinburgh Pharmacopœia gives the following directions for its preparation:—

Take of Sulphate of Iron, ℥iv.; Sulphuric Acid (commercial) fʒiijss.; Nitric Acid (D. 1380) fʒix.; stronger Aqua Ammoniæ, f℥iijss.; Water, Oij. Dissolve the sulphate in the water, add the Sulphuric Acid, and boil the solution; add then the Nitric Acid in small portions, boiling the liquid for a minute or two after each addition, until it acquires a yellowish-brown colour, and yields a precipitate of the same colour with ammonia. Filter; allow the liquid to cool; and add in a full stream the Aqua Ammoniæ, stirring the mixture briskly. Collect the precipitate on a calico filter; wash it with water till the washings cease to precipitate with nitrate of baryta; squeeze out the water as much as possible; and dry the precipitate at a temperature not exceeding 180°.

When this preparation is kept as an antidote for poisoning with arsenic, it is preferable to preserve it in the moist state, after being simply squeezed.

The protoxide of the sulphate is converted into sesquioxide by the oxygen of the nitric acid. The sesquioxide requires an additional quantity of sulphuric acid to form the neutral sulphate of the sesquioxide: $2(FeO,SO^3) + O + SO^3 = Fe^2O^3,3SO^3$. On the addition of caustic ammonia, the hydrated sesquioxide of iron is precipitated, while sulphate of ammonia remains in solution. The oxide retains in combination with it some ammonia, but this does not prove injurious to its therapeutical use. If potash or soda be substituted for ammonia, we obtain, unless the alkali be in excess, a subsulphate of iron instead of the hydrated oxide of iron; and if we use excess of alkali, a portion of it combines with the oxide. Oxide which has been precipitated by potash has been found not to be equally efficacious as an antidote for arsenic to that obtained by ammonia.[2]

PROPERTIES.—Hydrated sesquioxide of iron has a deep reddish-brown colour. Prepared for use, as an antidote to arsenious acid, it should be in the form of a soft or gelatinous moist magma. Though it may be dried at ordinary temperatures without undergoing decomposition, yet in this moist state it more readily renders arsenious acid insoluble; and, therefore, to preserve it in this condition it should be kept under water in a stoppered bottle. If this hydrated sesquioxide (prepared by ammonia) be added in considerable excess to a solution of arsenious acid, and well agitated, the filtered liquor gives no traces of the presence of arsenic. Dr. Maclagan states that "at least twelve parts of oxide, prepared by ammonia, are required for each part of arsenic;[3] and that when the oxide has either been precipitated by potash or been dried even at a low temperature, about three or four times larger quantities are requisite." That the arsenious acid has been rendered insoluble, is shown by the fact that by washing it cannot be removed from the magma.

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[1] Poggendorff, *Annalen d. Physik*, Bd. xxxii. S. 124, 1834; also, *Journal de Pharm.* xx. 567.

[2] See Bunsen's Memoir before quoted; also, Dr. Maclagan *On the Action of Hydrated Sesquioxide of Iron in Arsenic*, in the *Edinburgh Medical and Surgical Journal*, No. 144.

[3] "This proportion of twelve parts of the moist ammoniacal oxide to each part of arsenic, is that which has been indicated by several of the French experimentalists as being required to insure its antidotal effects."

The hydrated sesquioxide combines with arsenious acid, and yields a hydrated subarsenite of the sesquioxide of iron; the formula for which, as given by L. Gmelin on the authority of Bunsen, is $4Fe^2O^3,AsO^3,5HO$.

The formula given by Duflos is $2Fe^2O^3,AsO^3$. According to Guibourt[1] the composition of the subarsenite is *sesquioxide of iron* (calcined to redness), 65·0; *arsenious acid*, 14·50; *water*, 20·50. According to Professor Graham,[2] the mutual reaction of the hydrated sesquioxide and the arsenious acid gives rise to the formation of the arseniate of the protoxide of iron, $2Fe^2O^3+AsO^3=4FeO+AsO^5$.

COMPOSITION.—It consists of *sesquioxide of iron, water*, and a small portion of *ammonia*. One hundred parts of the magma, deprived of water by decantation, yielded Guibourt from 3·2 to 3·5 of calcined sesquioxide. According to the same authority, 1 litre of the magma, equal to about $1\frac{3}{4}$ imperial pints (1·7608 imperial pints), contains 32·35 grammes or $499\frac{6}{10}$ troy grains (499·6134 troy grains) of the calcined sesquioxide. So that one imperial pint contains about 286 grains of the calcined sesquioxide.

PHYSIOLOGICAL EFFECTS.—These are similar to those of the anhydrous sesquioxide before mentioned (see *ante*, p. 764).

USES.—Hydrated sesquioxide of iron has been employed as an antidote in poisoning by arsenious acid.

Drs. Bunsen and Berthold[3] were the first to assert the antidotal powers of this preparation. Their statements were confirmed by the experiments of Soubeiran and Miquel,[4] of Orfila and Lesueur,[5] of Bouley, jun.,[6] of Borelli and Demaria,[7] of Dr. Mackenzie,[8] of the Committee (composed of Drs. Deville, Nonat, and Sandras) appointed by the Société de Médecine of Paris,[9] and of other experimentalists.[10] On the other hand, Mr. Brett,[11] Mr. Orton,[12] Dr. Cramer,[13] and others, have denied its antidotal powers.

It is generally admitted that if a sufficiently large quantity of the hydrated sesquioxide be added to a solution of arsenious acid, it combines with the acid and forms an insoluble precipitate. In such cases the hydrated sesquioxide would act as a chemical antidote.

But it appears from the experiments of Dr. A. Taylor that when the hydrated sesquioxide is mixed with arsenious acid in the form of powder, that little or no chemical effect is produced. Now as in most cases of arsenical poisoning the arsenious acid is taken in the form of powder, it follows that in such the hydrated sesquioxide would not act as a chemical antidote; though it would doubtless be serviceable as a mechanical antidote (see *ante*, pp. 154,

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[1] *Journal de Chimie Méd.* t. v. 2de Série, p. 312.

[2] *Elements of Chemistry*, p. 636.

[3] *Op. cit.*

[4] *Journ. de Chim. Méd.* t. i. 2de Sér. p. 3.

[5] *Ibid.* p. 45.

[6] *Ibid.* p. 46.

[7] *Ibid.* p. 393.

[8] Quoted by Dr. Maclagan.

[9] *Journ. de Chim. Méd.* t. v. 2de Série, p. 317.

[10] Quoted by Dr. T. R. Beck, in *Lond. Med. Gaz.* Oct. 15, 1841.

[11] *Lond. Med. Gaz.* vol. xv. p. 220.

[12] *Lancet*, Nov. 8, 1834.

[13] Quoted by Dr. Alfred Taylor, *On Poisons*.

159, and 668). In thirty-one cases[1] in which it was given, recovery took place in twenty-nine. In one of these nearly two drachms of arsenic had been taken.[2] In the two unsuccessful cases the antidote could not be retained on the stomach.

ADMINISTRATION.—When exhibited as an antidote in arsenical poisoning it must be administered in very large doses. Dr. Maclagan says that twelve, Devergie, thirty-two, parts of the hydrated oxide are required for every part of arsenious acid swallowed. Dr. Beck recommends that it should be given in the quantity of a tablespoonful every five or ten minutes, or as often as the patient can swallow it. If hydrated sesquioxide be not at hand, let the common red oxide of iron be given with water as a substitute; for though not equally efficacious with the hydrated oxide, it appears to possess some antidotal power.[3]

136. FERRI CARBONAS.—CARBONATE OF IRON.

Formula FeO,CO^2. *Equivalent Weight* 58.

HISTORY.—This compound must not be confounded with the sesquioxide of iron, which is frequently termed carbonate of iron (see *ante*, p. 762).

NATURAL HISTORY.—It occurs native in the crystallized state, constituting the mineral called *spathose iron*. *Clay iron ore* is a native carbonate of iron (see *ante*, p. 756). Carbonate of iron is also found in the *carbonated chalybeate waters* (see *ante*, p. 297).

PREPARATION.—It is prepared by adding a solution of an alkaline carbonate to a solution of a protosalt (as the sulphate) of iron, the atmospheric air being carefully excluded. The hydrated carbonate of the protoxide of iron is precipitated.

By exposure to the air, oxygen is absorbed and carbonic acid is evolved.

Soubeiran[4] exposed this well-washed precipitate, in thin layers, to a moist atmosphere for three months: its composition was then found to be *sesquioxide* (quite free from protoxide) *of iron*, 71·4; *carbonic acid*, 8·3; and *water*, 20·0.

PROPERTIES.—Native protocarbonate of iron is yellow: the primary form of its crystals is the obtuse rhombohedron.

Carbonate of iron, prepared as above directed, is a white precipitate, which, by exposure to the air, becomes at first greenish, then brown (*sesquioxide*). It is insoluble in water, but dissolves in sulphuric or hydrochloric acid, with effervescence. It also readily dissolves in carbonic acid water: the *carbonated chalybeate waters* are natural solutions of this kind (see *ante*, p. 297).

Characteristics.—It dissolves in diluted sulphuric acid with effervescence. The solution possesses the before-mentioned properties of the ferruginous solutions (see *ante*, p. 758).

COMPOSITION.—Carbonate of the protoxide of iron is thus composed:—

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[1] Dr. T. R. Beck, *op. cit.*

[2] *London Medical Gazette*, vol. xix. p. 177.

[3] See *Journ. de Chim. Méd.* t. v. 2de Série, p. 305, et seq.

[4] *Journ. de Pharm.* t. xvi. 524.

	Atoms.	*Eq. Wt.*	*Per Cent.*	*Stromeyer.*
Protoxide of Iron	1	36	62	59·6276
Carbonic Acid	1	22	38	38·0352
Carbonate of Iron	1	58	100	97·6628

PHYSIOLOGICAL EFFECTS AND USES.—It is one of the most valuable of the ferruginous compounds, on account of the facility with which it dissolves in the fluids of the stomach, and becomes absorbed. Its local effects are very mild.

Its uses are those of chalybeates in general, and which have been before mentioned.

1. **FERRI CARBONAS SACCHARATUM**, E.; *Saccharine Carbonate of Iron.* (Sulphate of Iron, ℥iv.; Carbonate of Soda, ℥v.; Pure Sugar, ℥ij.; Water, Oiv. Dissolve the sulphate and carbonate each in two pints of the water; add the solutions and mix them; collect the precipitate on a cloth filter, and immediately wash it with cold water, squeeze out as much of the water as possible, and without delay triturate the pulp which remains with the sugar previously in fine powder. Dry the mixture at a temperature not much above 120°.)—Dr. Becker, of Mühlhausen, suggested this compound. His idea was carried out by Klauer:[1] and hence this preparation is known on the continent as Klauer's *ferrum carbonicum saccharatum*. The sugar checks, though it does not completely prevent, the further oxidation of the iron. This preparation is a greenish powder,[2] composed of *protoxide of iron*, *sugar*, and *carbonic acid*, with some *sesquioxide of iron*. Its characters are, according to the Edinburgh College, as follows:—

Colour greyish-green; easily soluble in muriatic acid, with brisk effervescence.

It may be given in doses of from five to ten grains.

2. **MISTURA FERRI COMPOSITA**, L. E. D.; *Compound Mixture of Iron; Steel Mixture; Griffith's Mixture.* (Myrrh, powdered, ʒij.; Carbonate of Potash, ʒj.; Rose water, f℥xviij.; Sulphate of Iron, powdered, ℈ijss.; Spirit of Nutmeg, f℥j.; Sugar, ʒij. Rub together the Myrrh with the Spirit of Nutmeg and the Carbonate of Potash; and to these, while rubbing, add first the Rose Water with the Sugar, then the Sulphate of Iron. Put the mixture immediately into a proper glass vessel, and stop it. *L.*—The processes of the *Edinburgh* and *Dublin Colleges* are essentially the same).—This is a professed imitation of Dr. Griffith's celebrated antihectic or tonic mixture.[3]

In the preparation of it double decomposition takes place: by the mutual reaction of carbonate of potash and sulphate of iron we obtain sulphate of potash, which remains in solution, and carbonate of protoxide of iron, which precipitates. To prevent the latter attracting more oxygen, it is to be preserved in a well-stoppered bottle. The quantity of carbonate of potash directed to be used is almost twice as much as is required to decompose the quantity of sulphate of iron ordered to be employed. The excess combines with the myrrh, and forms a kind of saponaceous compound, which assists in suspending the carbonate of iron in the liquid.

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[1] *Pharmaceutisches Central-Blatt für* 1836, S. 827; also, *Journ. de Pharmacie*, t. xxiii. p. 86.

[2] For some observations on its chemical properties, see a paper by A. Buchner, in the *Pharmaceutisches Central-Blatt für* 1837, S. 755.

[3] *Practical Observations on the Cure of Hectic and Slow Fevers, and the Pulmonary Consumption*, 1776.

When first made, this mixture has a greenish colour, owing to the hydrated ferruginous carbonate; but by exposure to the air it becomes reddish, in consequence of the absorption of oxygen, by which sesquioxide of iron is formed, and carbonic acid evolved: hence it should only be prepared when required for use.

It is one of the most useful and efficacious ferruginous preparations, and which is owing to its ready solubility, by which it is easily digested and absorbed. Its constitutional effects are analogous to those of the ferruginous compounds in general, and which have been already described. Its tonic and stimulant operation is promoted by the myrrh: the excess of alkaline carbonate must not be forgotten in estimating the sources of its activity.

It is admissible in most of the cases in which ferruginous remedies are indicated; but it is especially serviceable in anæmia, chlorosis, atonic amenorrhœa, and hysterical affections. It is also employed with benefit in the hectic fever of phthisis and chronic mucous catarrhs. It is contra-indicated in inflammatory conditions of the gastro-intestinal membrane.

The dose of it is one or two fluidounces three or four times a day. Acids and acidulous salts, as well as all vegetable astringents which contain gallic or tannic acid, are incompatible with it.

3. **PILULÆ FERRI COMPOSITÆ,** L. D.; *Pilulæ Ferri Carbonatis*, E.; *Pilulæ Ferri cum Myrrhâ*; *Compound Pills of Iron*; *Pills of Carbonate of Iron*. (Myrrh, powdered, ʒij.; Carbonate of Soda; Sulphate of Iron; Treacle, of each, ʒj. Rub the myrrh with the carbonate of soda; then having added the sulphate of iron, rub them again; afterwards beat the whole in a vessel previously warmed, until incorporated, *L.*—The *Dublin College* orders a drachm of Brown Sugar instead of Treacle.—The *Edinburgh College* orders of Saccharine Carbonate of Iron, *four parts*: Conserve of Red Roses, *one part*. Beat them into a proper mass, to be divided into five-grain pills.)—Prepared according to the London and Dublin Colleges these pills are analogous in composition, effects, and uses, to the preceding preparation. Double decomposition takes place between two salts employed, and the products are sulphate of soda and carbonate of iron. The carbonate of soda is preferred to the carbonate of potash, on account of the deliquescence of the latter. These pills, like the mixture, should only be made when required for use. The effects and uses of these pills are similar to those of the *Mistura Ferri composita*.—Dose, from grs. x. to grs. xx.

4. **FERRI SUPERCARBONAS;** *Supercarbonate of Iron.*—The supercarbonated chalybeates consist of carbonate of the protoxide of iron dissolved in water by the aid of carbonic acid. The *carbonated chalybeate mineral waters* (see *ante*, p. 297) are solutions of this kind.

These solutions are colourless, have a chalybeate flavour, and by exposure to the air give out carbonic acid, attract atmospheric oxygen, and let fall a reddish precipitate of the hydrated sesquioxide of iron.

Artificial solutions of the carbonated chalybeates are prepared in various ways. A convenient extemporaneous solution is obtained by mixing intimately sulphate of iron and bicarbonate of soda, and dissolving them in a tumblerful of carbonic acid water (*bottle soda water*). One hundred and thirty-nine grains of crystallized sulphate of iron require eighty-three grains of *sodæ sesquicarbonas*, L. to yield fifty-eight grains of carbonate of iron. It is advisable, however, to employ an excess of the sesquicarbonate of soda. If 10 grs. of sulphate of iron, and 10 grs. of the sesquicarbonate of soda, *L.* be used, we shall obtain a solution of about 4 grs. of carbonate of iron, 2½ grs. of sulphate of soda, and 5 grs. of sesquicarbonate of soda. The solution should be taken in a state of effervescence.

Another mode of preparing a solution of carbonate of iron is to add bicarbonate of soda to a solution of sulphate of iron acidulated by some acid, as sulphuric, tartaric, or citric acid.

137. Ferri Phosphates.—Phosphates of Iron.

There are several compounds formed by the union of phosphoric acid with the oxides of iron. Of these, three have been employed in medicine.

1. Ferri Phosphas, Ph. U.S.; *Phosphate of Iron; Ferrum phosphoricum cæruleum; Ferrum phosphoricum oxydulatum cum oxydo ferri; Phosphas ferroso-ferricus; Ferrum oxydo-oxydulatum; Blue Phosphate of Iron.*—The United States Pharmacopœia directs it to be thus prepared:—"Take of Sulphate of Iron, ℥v.; Phosphate of Soda, ℥vj.; Water, *Cong.* j. Dissolve the sulphate of iron and phosphate of soda severally in four pints of the water; then mix the solutions, and set the mixture by that the powder may subside; lastly, having poured off the supernatant liquor, wash the phosphate of iron with hot water, and dry it with a gentle heat."

By the mutual action of sulphate of the protoxide of iron and phosphate of soda, we obtain the tribasic phosphate of the protoxide of iron, which is precipitated, and sulphate of soda, with excess of sulphuric acid, is left in solution. $3(FeO,SO^3)+HO,2NaO,cPO^5=3FeO,cPO^5+2(NaO,SO^3)+HO,SO^3$.

The tribasic phosphate of the protoxide of iron ($3FeO,cPO^5$) is a white powder, which is insoluble in water; but is soluble in dilute acids, as well as in ammonia. By exposure to the air it absorbs oxygen, and acquires a blue colour. Its formula in this state is, according to Rammelsberg,[1] $2(3FeO,cPO^5+8HO)+(3Fe^2O^3,2cPO^5,8HO)$. But Wittstein[2] asserts that its constitution is inconstant; and that the proportion of protophosphate in it to that of perphosphate varies from 9:1 to 2:1.

Wiltstein says it is impossible to produce it by adding a solution of phosphate of soda to the solution of the mixed sulphates of iron.

The *Codex Medicamentarius Hamburgensis* directs that when phosphate of iron *(ferrum phosphoricum)* simply is ordered, without the addition of the word oxidated *(oxydatum)*, this blue phosphate is to be employed. The same rule may be conveniently followed in England.

Its effects, uses, and doses are similar to those of the following preparation. It was employed by Mr. Carmichael[3] (who calls it the phosphate of iron) in the treatment of cancer. He administered it both externally and internally. But for internal use he preferred the suboxyphosphate of iron to this blue phosphate. Applied topically to cancerous ulcers it caused less pain than the suboxyphosphate. Dr. Venables[4] proposed this preparation in the treatment of diabetes. He speaks in the highest terms of its power to restrain the excessive secretion of urine, to reduce the bulimia, and to invigorate and increase the powers of digestion. Dr. Prout[5] has borne favourable testimony to its effect. It is, he says, an excellent remedy, and he is disposed to think very favourably of it.

2. Ferri Perphosphas; *Ferri Oxyphosphas; Ferri Sesquiphosphas; Perphosphate, Oxyphosphate, Sesquiphosphate,* or *White Phosphate of Iron; Ferrum phosphoricum album*

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[1] *Annalen d. Chemie*, Bd. lvi. S. 210, 1845.

[2] Buchner's *Repertorium*, 2ter Reihe; Bd. xxxxix; S. 145, 1845.

[3] *An Essay on the Effects of Carbonate and other Preparations of Iron in Cancer*, pp. 35, 341-343, 1809.

[4] *A Practical Treatise on Diabetes*, pp. 70-71, 1825.

[5] *On the Nature and Treatment of Stomach and Urinary Diseases*, 3d edit. p. 48, 1840.

vel oxydatum; Phosphas ferricus.—This salt is obtained by mixing a solution of phosphate of soda with a solution of a persalt of iron: white perphosphate of iron is precipitated, while a salt of soda remains in solution. The precipitate is a basic phosphate, which, when dried at from 122° F. to 140° F., consists, according to Wittstein, of Fe^2O^3,cPO^5+8HO; but when dried at 212°, its formula is Fe^2O^3, cPO^5+4HO, as given by Rammelsberg. The phosphate obtained by the action of caustic ammonia on a solution containing sesquioxide of iron and phosphoric acid is $3Fe^2O^3,2cPO^5+16HO$; but by repeated washing the proportion of oxide to acid is 2 to 1.

Perphosphate of iron is a white powder, insoluble in water, but soluble, by means of a gentle heat, in dilute nitric acid. It is unalterable in the air. Heated to redness it is deprived of water, and becomes brown.

The perphosphate of iron was employed by Mr. Carmichael in the same way and for the same purposes as the preparation above mentioned. He calls it the *oxyphosphate of iron*, and says that the blue phosphate was frequently sold in the shops for it.

Under the name of "oxyphosphate of iron" Fuzet-Dupouget[1] has recently used in cancerous diseases the perphosphate mixed with some protophosphate. He says it is prepared by adding a solution of phosphate of soda to a solution of sulphate of iron which has been exposed to light and air until it has acquired the brown colour of Madeira wine. He employed it as a palliative to allay pain, to remove the unpleasant odour of the discharge, and to restrain the progress of the disease. He gave it internally, and applied to the part the filtered liquor (sulphate of soda!) from which the phosphate had been precipitated.

This, as well as the preceding preparation, may be given in doses of from two to ten grains in the form of powder, pill, or electuary. Externally they may be applied in the form of a dusting powder, (either alone or mixed with gum or sugar), in the form of paste, of lotion, and of ointment. Mr. Carmichael thinks that the best mode of using them is to blend them with water to the consistence of a thin paste, with which the surface of the ulcer should be covered. It may be employed also in the form of lotion, prepared by diffusing the phosphate through water. An ointment (composed of ʒij. of phosphate to ℥j. of fat) has been used; but Mr. Carmichael found that this was a less efficacious method of employing the phosphate.

Liquor Ferri Superphosphatis; Solutio Ferri Oxydati in Acido Phosphorico; Liquor Schobeltii.—This is an aqueous solution of superphosphate of iron, which was employed by Schobelt in decayed teeth, and for the relief of toothache. It is a solution of the perphosphate in aqueous phosphoric acid. Lint, moistened with about twenty drops of the solution, is introduced into the cavity of the tooth.

3. Ferri Subperphosphas; *Subperphosphate of Iron; Suboxyphosphate of Iron.*—This salt is prepared by boiling the perphosphate of iron with a solution of caustic potash. A brownish-red powder is obtained, whose composition, according to Rammelsberg, is $15Fe^2O^3, cPO^5$; but, according to Wittstein[2], it consistses sentially of sesquioxide of iron, with some phosphoric acid and potash. It is scarcely soluble in acids or in water. Mr. Carmichael preferred this, for internal use, to the other phosphates. Applied to cancerous ulcers it excites a very severe smarting sensation. When sprinkled over the common earth worm, it kills the animal, he says, more rapidly than the other phosphates, or even than arsenious acid. The dose of it is from grs. ij. to grs. x. given in the form of pills.

138. FERRI SULPHURETUM.—SULPHURET OF IRON.

Formula FeS. *Equivalent Weight* 44.

HISTORY.—This preparation was formerly called *chalybs cum sulphure præparatus*.

NATURAL HISTORY.—In the mineral kingdom sulphur and iron are frequently met with in combination.

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[1] Dierbach, *Die neuesten Entdeckungen in der Mat. Med.* Bd. ii. S. 1322, 1843; and Buchner's *Repert.* 2te Reihe, Bd. ix. H. 3, S. 358, 1837.

[2] Buchner's *Repertorium*, 2ter Reihe, Bd. xli. S. 44, 1846.

Magnetic pyrites, Fe^7S^8, occurs at Kongsberg, in Norway, at Andreasberg, in the Hartz, and at other places.

Sulphuret of iron, FeS, is found in small quantity in some meteoric stones. It is sometimes formed by the action of decomposing organic matter on solutions of sulphate of iron.[1]

Common or *yellow iron pyrites*, usually called *mundic*, is a bisulphuret of iron, FeS^2. It occurs in Cornwall, Derbyshire, &c. *White iron pyrites*, *radiated pyrites*, or *cockscomb pyrites*, is also FeS^2, but differs from mundic in the shape of its crystal, its specific gravity, and its strong tendency to decompose on exposure to the air and to furnish an efflorescence of sulphate of iron. The radiated pyrites rolled amongst the shingles upon the sea-beach are popularly termed *thunder-bolts*. Iron pyrites (FeS^2) is used in the manufacture of oil of vitriol (see *ante*, p. 348), and for the preparation of sulphate of iron.

PREPARATION.—Directions for the preparation of sulphuret of iron are given in both the Edinburgh and Dublin Pharmacopœias.

The *Edinburgh College* states that "the best sulphuret of iron is made by heating an iron rod to a full white heat in a forge, and rubbing it with a roll of sulphur over a deep vessel filled with water, to receive the fused globules of sulphuret which form. An inferior sort, good enough, however, for pharmaceutic purposes, is obtained by heating one part of sublimed sulphur and three of iron filings in a crucible in a common fire till the mixture begins to glow, and then removing the crucible and covering it, until the action, which at first increases considerably, shall come to an end."

The *Dublin College* direct, that a rod of iron should be exposed to the strongest heat of a forge, until it becomes white hot, and, when taken from the fire, let it instantly be applied to a solid mass of sulphur. Let the sulphuret of iron be received in water; and, when separated from the sulphur and dried, let it be preserved in closed vessels.

The sulphur and iron enter into combination, and form sulphuret of iron, FeS.

PROPERTIES.—The appearance of sulphuret of iron varies somewhat according to the mode of procuring it. If properly prepared it gives out abundance of sulphuretted hydrogen gas, when mixed with either diluted sulphuric or muriatic acid, while a ferruginous solution is obtained.

COMPOSITION.—Its composition is liable to some variation. The best is a protosulphuret of iron, and has the following composition:—

	Atoms.	*Eq. Wt.*	*Per Cent.*	*Hatchett.*	*Bucholz and Gehlen.*
Iron	1	28	63·6	63·5	63·4
Sulphur	1	16	36·4	36·5	36·6
Sulphuret of Iron	1	44	100·0	100·0	100·0

Sometimes, however, a compound containing a larger proportion of sulphur is found.

PHYSIOLOGICAL EFFECTS AND USES.—Sulphuret of iron is principally employed for the preparation of sulphuretted hydrogen (see *ante*, p. 363). Biett and Cazenave,[2] however, have employed it in the treatment of cutaneous maladies. The last-mentioned physician considers that it agrees with levigated iron in its effects on the system. It provokes eructations of sulphuretted hydrogen. In cutaneous maladies of a scrofulous character it proved a valuable alterative, and was more serviceable than iodine. It appeared to be less irritating, and less apt to excite suppuration in scrofulous swellings. Biett gave it in obstinate lichen agrius.

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[1] Pepys, *Trans. of the Geological Society*, vol. i. p. 399.

[2] Bourchardat, *Nouveau Formulaire magistral*, p. 204, 3me. ed. 1845.

ADMINISTRATION.—The dose is from gr. iv. to gr. xij., taken in syrup, or in the form of pill.

FERRI SULPHURETUM HYDRATUM; *Hydrated Protosulphuret of Iron.*—The black mud and filth of privies, drains, ponds, bogs, &c. is due to the presence of the hydrated sulphuret of iron formed by the action of decomposing sulphur compounds on ferruginous earths. Organic substances containing sulphur as well as sulphates in contact with decomposing organic matters, furnish the sulphur. The fæces, after the use of chalybeates, owe their black colour to the same compound.

It is obtained by adding an alkaline sulphuret to a solution of protosulphate of iron in recently-boiled or distilled water. $FeO,SO^3 + KS = KO,SO^3 + FeS$. If hydrosulphuret of ammonia be used, the equation is as follows:—$FeO,SO^3 + NH^3,2HS = FeS + NH^3,SO^3 + HS$. The precipitate should be washed with recently-distilled or boiled water.

It is a black substance, insoluble in water. By exposure to the air it absorbs oxygen, and is converted into the sulphate of iron. $FeS + 4O = FeO,SO^3$. Hence it should be preserved in well-stoppered bottles filled with recently distilled or boiled water, in order to exclude atmospheric air.

Mialhe[1] has proposed this agent as an antidote for poisoning by corrosive sublimate, the products of the reaction between these substances being protochloride of iron and sulphuret of mercury. $FeS + HgCl = FeCl + HgS$. He says that a gargle containing this hydrated sulphuret will instantly remove the metallic taste caused by putting a minute quantity of corrosive sublimate into the mouth. Mialhe also asserts that this sulphuret will render innocuous the salts of tin, antimony, silver, and arsenious acid. Orfila[2] states, as the result of his experiments, that if taken *immediately* after the ingestion of the poison, the hydrated protosulphuret completely destroys the poisonous quality of corrosive sublimate; but that if not exhibited until ten or fifteen minutes after the poison has been swallowed, it is useless.

Bourchardat and Sandras[3] have proposed to substitute what they call the *hydrated persulphuret of iron* for the hydrated protosulphuret; and they propose to obtain it by adding an alkaline sulphuret to a solution of a persalt of iron.

139. FERRI SULPHAS.—SULPHATE OF IRON.

Formula FeO,SO^3. *Equivalent Weight* 76.

HISTORY.—Sulphate of iron is one of the substances which Pliny[4] termed *chalcanthum*. This is evident from the circumstance of his statement, that the Romans called it *atramentum sutorium*, or *shoemaker's black*. It is frequently termed *copperas*, and in consequence has been sometimes confounded with the salts of copper:[5] *green vitriol* (*vitriolum viride*), *vitriol of mars*

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[1] Mialhe, *Traité de l'Art de Formuler*, p. 110, 1845.

[2] *Traité de Toxicologie*, t. i. p. 718, 1843.

[3] *Bulletin de Thérapeutique*, Août 1843.

[4] *Hist. Nat.* xxxiv. 32.

[5] Dr. Cummin, *Lond. Med. Gaz.* xix. 40.

(*vitriolum martis vel vitriolum martiale*), *salt of mars* (*sal martis*), *and vitriolated iron* (*ferrum vitriolatum*), are other names by which it is known.

NATURAL HISTORY.—This salt is found native associated with iron pyrites, by the decomposition of which it is formed; and it occurs in the waters of several mines. It is rarely met with native in the crystallized state. It occurs, however, in the Rammelsberg mine, near Goslar; at Schwartzenburg, in Saxony; in the aluminous shale[1] at Hurlet, near Paisley (see *ante*, p. 622); and in New England.

Sulphate of the protoxide of iron is found in some of the sulphated chalybeate mineral waters (see *ante*, p. 296); as those of the Selken-brunnen at Alexisbad, of Mscheno in Bohemia, and of Buckowina in Silesia.

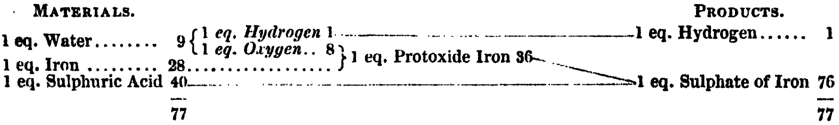
PREPARATION.—Sulphate of the protoxide of iron is prepared by dissolving clean unoxidized iron in diluted sulphuric acid.

The *London College* orders, of Iron Filings, ℥viij.; Sulphuric Acid, ℥xiv.; Water, Oiv. Mix the Sulphuric Acid with the Water, and add the Iron to them; then apply heat, and when bubbles have ceased to escape, strain the liquor, and set it aside that crystals may be formed. Evaporate the liquor poured off, that it may again yield crystals. Dry them all.

The *Edinburgh College* observes, that if the Sulphate of Iron of commerce be not in transparent green crystals, without efflorescence, dissolve it in its own weight of boiling water, acidulated with a little sulphuric acid: filter, and set the solution aside to crystallize. Preserve the crystals in well-closed bottles.

The *Dublin College* orders, of Iron Wire, *four parts*; Sulphuric Acid, *seven parts*; Water, *sixty parts*.

In this process one equivalent of iron decomposes one equivalent of water, combines with an equivalent of oxygen, and sets free an equivalent of hydrogen. The equivalent of protoxide of iron combines with an equivalent of sulphuric acid to form an equivalent of sulphate of iron. $Fe + HO,SO^3 = FeO,SO^3 + H$.



The *common green vitriol*, or *copperas*, or *crude sulphate of iron*, of the shops, is prepared by exposing heaps of moistened iron pyrites (bisulphuret of iron) to the air for several months. In some places the ore is previously roasted. The moistening is effected by rain or by manual labour. Both constituents (iron and sulphur) are oxidized: the products are protoxide of iron and sulphuric acid. But as the quantity of sulphuric acid formed is greater than is sufficient to saturate the protoxide of iron, the excess is saturated either by the alumina contained in the clay mixed with the pyrites, or by the addition of old iron. If alumina be used to saturate it, the equation will be as follows:—$3FeS^2 + Al^2O^3 + 21O = 3(FeO,SO^3) + Al^2O^3,3SO^3$. The liquid is concentrated in leaden boilers, and runs off into large vessels lined with lead, where the sulphate of iron crystallizes. The sulphate of alumina remains in the mother liquor, and is converted into alum by the addition of sulphate of potash. If, however, metallic iron be used to saturate the excess of sulphuric acid, the equation will be as follows:—$FeS^2 + F + 8O = 2(FeO,SO^3)$.

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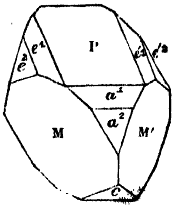
[1] According to Dr. Thomson (*Outlines of Mineralogy*, vol. i. p. 472, 1836), the sulphate found at Hurlet and Campsie was an *alumina-sulphate of iron*.

FIG. 138.



Crystal of Sulphate of Iron.

PROPERTIES.—Sulphate of the protoxide of iron crystallizes in transparent pale bluish-green crystals, the form of which is the oblique rhombic prism. Their sp. gr. is 1·82. They have an acid, styptic taste, and redden litmus. When heated to 212° F., they give out 6 equivalents of water, and at a higher temperature lose their remaining equivalent of water. In the anhydrous state the salt is white, pulverulent, and astringent.

When the anhydrous salt is heated to redness, it is resolved into sesquioxide of iron, sulphurous acid, and anhydrous sulphuric acid: the two latter are volatilized. $2(FeO,SO^3) = Fe^2O^3 + SO^3 + SO^2$.

Sulphate of iron which is quite devoid of the sulphate of the sesquioxide, and which has been crystallized from perfectly neutral liquors, has a greenish-blue tint like that of the beryl. In commerce there are three varieties of sulphate of iron. The first is blue, with a slight tint of green, and has been obtained by crystallizing it from acid liquors. The second is pale green, and has been formed in neutral liquors. The third is of an emerald-green colour, and has been produced in liquors which contain a considerable quantity of the sulphate of the sesquioxide (Pelouze and Fremy).

By exposure to the air, the crystals of sulphate of iron absorb oxygen, become greener, then slightly efflorescent and somewhat opake, and ultimately acquire a yellow or ochry covering of the basic sulphate of the sesquioxide, $2(Fe^2O^3),SO^3$.

Crystallized sulphate of iron is soluble in water, but insoluble in alcohol. It requires two parts of cold, and three-fourths of its weight of boiling water, to dissolve it. The solution has a bluish-green colour, but by exposure to the air it attracts oxygen, becomes deep green, and deposits a basic sulphate of the sesquioxide, $2(Fe^2O^3),SO^3$. The liquor retains in solution a salt whose base is the deutoxide or magnetic oxide, FeO,Fe^2O^3. By the prolonged action of air on the solution, the colour becomes reddish-yellow, and the sulphate is entirely converted into the neutral sulphate of the sesquioxide ($Fe^2O^3,3SO^3$) and the basic sulphate, $2(Fe^2O^3),SO^3$.

Characteristics.—It is known to be a sulphate by a solution of a barytic salt (see *ante*, p. 355).

Its characters as a protosalt of iron have been before stated (see *ante*, p. 758).

The remarkable effect of binoxide of nitrogen on its solution has been already pointed out (see *ante*, p. 408).

The sulphate of iron of the shops almost invariably contains traces of the sulphate of the sesquioxide. Hence the precipitate which it yields with ferrocyanide of potassium is usually bluish.

COMPOSITION.—The composition of this salt is as follows:—

	Atoms.	*Eq. Wt.*	*Per Cent.*	*Berzelius.*	*Thomson.*
Protoxide of Iron	1	36	25·9	25·7	26·7
Sulphuric Acid	1	40	28·8	28·9	28·3
Water	7	63	45·3	45·4	45·0
Crystallized Sulphate of the Protoxide of Iron	1	139	100·0	100·0	100·0

PURITY.—This salt is frequently mixed with sulphate of the sesquioxide:

this may be known by the yellowish-green colour of the crystals, and by the blue colour produced on the addition of ferrocyanide of potassium.

Colour bluish green; dissolved by water. Iron put into the solution does not precipitate copper.—*Ph. Lond.*

Pale bluish-green crystals, with little or no efflorescence.—*Ph. Ed.*

The *common green vitriol*, or *copperas*, of the shops is a mixture of the sulphates of the protoxide and sesquioxide of iron. It is liable to be contaminated with the salts of copper, zinc, manganese, alumina, magnesia, and lime. Copper may be recognised and removed from it by immersing a clean iron spatula in a solution of it: the iron becomes encrusted with copper. Copper may also be detected by adding excess of caustic ammonia to the ferruginous solution and filtering the liquor. If copper be present, the liquor will have an azure blue tint. The ammoniacal liquid should yield, by evaporation, no fixed residuum. It is difficult to deprive the salt of the other impurities above mentioned.

PHYSIOLOGICAL EFFECTS. α. *On Vegetables.*—Sir H. Davy[1] ascribes the sterility of a soil to the presence of sulphate of iron.

β. *On Animals.*—C. G. Gmelin[2] found that two drachms of sulphate of iron given to a dog caused vomiting only,—that forty grains had no effect on a rabbit,—and that twenty grains, thrown into the jugular vein of a dog, produced no effect. Dr. Smith,[3] however, found that two drachms proved fatal to a dog when taken into the stomach or applied to a wound. Orfila[4] obtained similar results. The effects were local inflammation and a specific affection of the stomach and rectum. According to Weinhold,[5] the spleen of animals fed with it becomes remarkably small and compact.

γ. *On Man.*—This salt acts locally as a powerful astringent, and, when employed in a concentrated form, as an irritant. The latter effect depends on its chemical action on the organic constituents (albumen, &c.) of the tissues. The remote effects of sulphate of iron are analogous to those of other ferruginous compounds, and which have been already described.

Swallowed *in small doses*, it has an astringent operation on the gastro-intestinal mucous membrane, and thereby diminishes the quantity of fluids secreted or exhaled: hence its continued use causes constipation. It blackens the stools like other compounds of iron. It becomes absorbed, and operates on the system as a tonic, stimulant, emmenagogue, and astringent. *In large medicinal doses* it readily excites pain, heat, or other uneasiness at the pit of the stomach, and not unfrequently causes nausea and vomiting: this is especially the case in irritable conditions of this viscus. *In excessive doses* it operates as an irritant poison. A girl took, as an emmenagogue, an ounce of it in beer, and was seized in consequence with colic pains, constant vomiting, and purging for seven hours. Mucilaginous and oily drinks soon cured her.[6]

A case is recorded by Mr. Moore[7] in which contractions of the flexors of the hands and feet, with headache and sickness, occurred in a boy who had been engaged in picking the crystals of the sulphate from their mother liquor.

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[1] *Agricultural Chemistry.*

[2] *Vers. u. d. Wirk*, &c. 84.

[3] Quoted by Wibmer and by Christison.

[4] *Toxicol. Gén.*

[5] Quoted by Richter, *Ausf. Arzneim.* v. 55.

[6] Christison, from Rust's *Magazin*, xxi. 247.

[7] *London Medical Gazette*, May 27, 1842.

USES.—Sulphate of iron is to be preferred to other ferruginous compounds where there is great relaxation of the solid parts, with immoderate discharges. Where the long-continued use of ferruginous compounds is required, it is less adapted for administration than some other preparations of iron, on account of its local action on the alimentary canal.

It is employed in lump, powder, or solution, as a styptic, to check hemorrhage from numerous small vessels. A solution of it is applied to ulcerated surfaces and to mucous membranes to diminish profuse discharges, as in chronic ophthalmia, leucorrhœa, and gleet. Mr. Vincent used it in prolapsus ani (see *ante*, p. 194). A solution of three drachms of the sulphate in five ounces of water has been used by Velpeau to repress erysipelas.

Internally, it is administered in passive hemorrhages, on account of its supposed astringent influence over the system generally; also in immoderate secretion and exhalation—as in humid asthma, chronic mucous catarrh, old dysenteric affections, colliquative sweating, diabetes, leucorrhœa, gleet, &c. In intermittents it has been employed as a tonic. It has also been found serviceable against tape-worm. Its other uses are the same as the ferruginous compounds before mentioned.

ADMINISTRATION.—The dose of it is from one to five grains in the form of pill. If given in solution, the water should be recently boiled, to expel the atmospheric air dissolved in it, the oxygen of which converts this salt into a persulphate. A very agreeable method of exhibiting sulphate of iron is in solution in carbonic acid water. Mr. Webb prepared it for me of three strengths: one containing three grains, a second six grains, a third nine grains of the crystallized sulphate to each bottle of carbonic acid water (bottle soda water).

For local purposes, solutions of it are employed of various strengths, according to circumstances. In chronic ophthalmia, we may use one or two grains to an ounce of water; as an injection in gleet, from four to ten grains. It has been used to disinfect night soil:[1] the products are sulphate of ammonia and hydrated sulphuret of iron.

1. **FERRI SULPHAS EXSICCATUM**, E.; *Dried Sulphate of Iron.* (Expose any convenient quantity of Sulphate of Iron to a moderate heat in a porcelain or earthenware vessel, not glazed with lead, till it is converted into a dry greyish-white mass, which is to be reduced to powder.)—By exposure to a moderate heat, the crystals lose $\frac{6}{7}$ths of their water of crystallization; so that 85 grains of dried sulphate are equivalent to 139 grains of the crystallized sulphate, or 3 grains are equal to $4\frac{9}{10}$ grains of the crystals. The dried sulphate is used in the following preparation.

2. **PILULÆ FERRI SULPHATIS**, E.; *Pills of Sulphate of Iron.* (Dried Sulphate of Iron, *two parts;* Extract of Taraxacum, *five parts;* Conserve of Red Roses, *two parts;* Liquorice-root powder, *three parts.* Beat them together into a proper mass, which is to be divided into five-grain pills.)—Each pill should contain $\frac{5}{6}$th of a grain of dried sulphate of iron.—Dose, one to three pills.

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[1] *Comptes Rendus,* xix. 114.

140. Ferri Persulphas.—Persulphate of Iron.

Formula $Fe^2O^3,3SO^3$. *Equivalent Weight* 200.

Sulphate of the Sesquioxide of Iron; Persesquisulphate of Iron; Oxysulphate of Iron.—Persulphate of iron is a constituent of some of the sulphated chalybeate waters (see *ante*, p. 297); as the strong Moffat chalybeate, the Vicar's Bridge chalybeate, and the Cransac manganesian waters. There are several native mineral compounds of sulphuric acid and the sesquioxide of iron, such as *coquimbite*, *yellow copperas*, *fibro-ferrite*, and *pittizite* or *vitriol-ochre*. Persulphate of iron is frequently made by peroxidizing the protosulphate by means of nitric acid. $2FeO,SO^3+O=Fe^2O^3,2SO^3$. In order to convert this sub-persulphate ($Fe^2O^3,2SO^3$) into the neutral sulphate of the sesquioxide, an additional equivalent of sulphuric acid is required for every two equivalents of the protosulphate. $Fe^2O^3,2SO^3+SO^3=Fe^2O^3,3SO^3$. This salt has been used in the preparation of the hydrated persulphuret of iron.

In 1842, Mr. Tyson[1] published the formula for making a solution of the sulphate of the sesquioxide of iron, which he calls the *liquor oxysulphatis ferri*. He says it was invented by Sylvester about forty years ago, and has been ever since in constant use among the practitioners in Derbyshire. The following is the method of preparing it:—

Take of Sulphate of Iron, ℥ij. or ℥iij.; Nitric Acid, ʒiij.; Distilled Water, ℥iss. Rub the acid with the sulphate for a quarter of an hour, then gradually add the water, and strain through paper. The dose of this solution is from five to twelve drops twice a day in infusion of quassia, or in water.

Persulphate of iron acts topically as a powerful astringent and mild caustic, like the pernitrate and perchloride. It combines with albumen to form a pale yellowish compound;[2] on this property depends its chemical action on the tissues. Its remote effects are those of a tonic and hæmatinic, like the other chalybeates.

Its uses are similar to those of the other persalts of iron. It may be given in conjunction with small doses of sulphate of magnesia as an artificial chalybeate purging water. Dr. Osborne[3] says, Widow Welch's pills are composed of "sulphate of peroxide of iron, with a small quantity of insipid vegetable matter, probably gum, as much as is requisite for adhesion." It is more probable, however, that they are prepared with the common sulphate of the shops, which is a mixture of protosulphate and persulphate of iron.

141. FERRI SESQUICHLORIDUM.—SESQUICHLORIDE OF IRON.

Formula Fe^2Cl^3. *Equivalent Weight* 162·5.

HISTORY.—This chloride was known in the 17th century, but it was first accurately described by Sir H. Davy in 1811. It is sometimes called the *perchloride of iron*, and, when combined with water, the *permuriate of iron*.

NATURAL HISTORY.—Sesquichloride of iron is a constituent of the mineral called *pyrosmalite*.

Some mineral waters contain the protochloride of iron, $FeCl$; as those of Alexisbad and of Buckowina.

PREPARATION.—For medicinal purposes sesquichloride of iron is obtained by dissolving sesquioxide of iron in hydrochloric acid. $Fe^2O^3+3HCl=Fe^2Cl^3+3HO$. By evaporation, the hydrated sesquichloride is obtained in a crystalline form.

PROPERTIES.—Sesquichloride of iron is a volatile solid. It deliquesces in the air, and forms the liquid formerly called *oil of iron* (*oleum martis*). The sesquichloride is soluble in water, alcohol, and ether. The ethereal solution, by exposure to solar light, is decolourized, and lets fall the protochloride of iron (FeCl). The aqueous solution deposits the brown pulverulent oxichloride, $Fe^2Cl^3,6Fe^2O^3,9HO$.

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[1] *Pharmaceutical Journal*, vol. i. p. 598, 1842.

[2] *Journ. de Chim. Méd.* t. vi. 2e série, p. 308.

[3] *Lond. Med. Gaz.* March 6, 1840, p. 892.

Characteristics.—It is known to be a persalt of iron by the before-mentioned tests for this class of salts (see *ante*, p. 758).

It is known to be a chloride by the tests for the chlorides before stated (see *ante*, p. 369).

COMPOSITION.—The anhydrous sesquichloride has the following composition:—

	Atoms.	*Eq. Wt.*	*Per Cent.*	*J. Davy.*
Iron	2	56	34·46	35·1
Chlorine	3	106·5	65·54	64·9
Sesquichloride of Iron	1	162·5	100·00	100·0

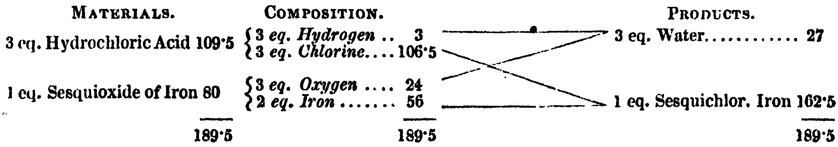
Ellerman's disinfecting fluid is essentially a solution of a persalt of iron. It is usually a mixture of a solution of sesquichloride of iron (made by dissolving the residue of the combustion of iron pyrites in hydrochloric acid) and of an impure solution of the persalt of iron. To this is commonly added the refuse solution of chloride of manganese resulting from the manufacture of chlorine. It decomposes the hydrosulphurets, and destroys the offensive odour of night soil, and other kinds of decomposing organic matter.

TINCTURA FERRI SESQUICHLORIDI, L.; *Tincture of Sesquichloride of Iron*; *Ferri Muriatis Tinctura*, E.; *Tincture of the Muriate of Iron*; *Muriatis Ferri Liquor*, D.; *Solution of Muriate of Iron*.—All the British Colleges give directions for its preparation.

The *London* and *Edinburgh Colleges* order of Sesquioxide of Iron, ℥vj.; Hydrochloric Acid, Oj.; Rectified Spirit, Oiij. Pour the Acid upon the Sesquioxide of Iron in a glass vessel, and digest for three days, frequently shaking. Lastly, add the Spirit, and strain.

The *Dublin College* orders, of Rust of Iron, *one part*; Muriatic Acid; Rectified Spirit, of each, *six parts*. Pour the acid on the rust passed into a glass vessel, and occasionally stir the mixture during three days; then set it apart that the dregs may subside, and pour off the clear liquor: by slow evaporation reduce this to one-third part, and when cold add to it the spirit.

By digestion in hydrochloric acid the sesquioxide becomes the sesquichloride of iron, while water is formed.



As the sesquichloride of iron employed frequently contains a small portion of protocarbonate of iron, a little protochloride of iron is formed, and slight effervescence, owing to the escape of carbonic acid, takes place. Both the chlorides of iron are soluble in water as well as in spirit.

This tincture is of a reddish-brown colour, and stains white paper yellow. It has a sour styptic taste, and an odour of hydrochloric ether, from which it would appear that a mutual reaction takes place between the hydrochloric acid and the alcohol. It reacts on vegetable colours as an acid. "Its sp. gr. is about 0·992, and a fluid ounce yields, when decomposed by potash, nearly 30 grains of sesquioxide of iron."[1]

Characteristics.—Its reaction on vegetable colours, its inflammability, its remarkable odour, and its reactions as a persalt of iron and as a chloride (see *supra*), are properties sufficient to characterize it. It forms a brown semi-transparent jelly with mucilage of gum arabic.

COMPOSITION.—This tincture consists of *rectified spirit,* a small portion of *hydrochloric ether, hydrochloric acid, sesquichloride of iron,* and frequently a small portion of *protochloride of iron.* Unless excess of hydrochloric acid be present, sesquioxide (oxichloride?) of iron is thrown down when the tincture is exposed to the air.

PURITY AND STRENGTH.—The commercial tincture of sesquichloride of iron varies in its strength, owing to the varying density of the hydrochloric acid employed; and perhaps also on the condition of the sesquioxide; for when this has been calcined it is less readily soluble in acids. Moreover, a diluted spirit is frequently substituted for rectified spirit. These differences can only be discovered by examining the colour and specific gravity of the tincture, as well as the quantity of oxide which it yields.

PHYSIOLOGICAL EFFECTS.—Tincture of sesquichloride of iron is, in its local action, one of the most powerful of the preparations of iron. It acts as an energetic astringent and styptic, and in large doses as an irritant. The large quantity of free hydrochloric acid which the tincture of the shops frequently contains, contributes to increase its irritant properties; and in Dr. Christison's *Treatise on Poisons* is a brief notice of a case in which an ounce and a half of this tincture was swallowed, and death occurred in about six weeks—the symptoms during life, and the appearances after death, being those indicative of inflammation of the alimentary canal. When swallowed in large medicinal doses it readily disorders the stomach. The general or constitutional effects of this preparation agree with those of other ferruginous compounds. It appears to possess, in addition, powerfully diuretic properties. Indeed, it would seem to exercise some specific influence over the whole of the urinary apparatus; for, on no other supposition can we explain the remarkable effects which it sometimes produces in affections of the kidneys, bladder, urethra, and even the prostate gland. It colours the fæces black, and usually constipates the bowels.

USES.—It is sometimes, though not frequently, used as a topical agent. Thus it is applied as a *caustic* to venereal warts, and to spongy granulations. As an *astringent* it is sometimes employed as a local application to ulcers attended with a copious discharge; or as a *styptic* to stop hemorrhage from numerous small vessels.

Internally it may be employed as a *tonic* in any of the cases in which the other ferruginous compounds are administered, and which I have already mentioned. It has been especially commended in scrofula.

In various affections of the urino-genital organs it is frequently used with great success. Thus, in retention of urine, arising from spasmodic stricture, its effects are sometimes beneficial. It should be given in doses of ten minims every ten minutes until benefit is obtained, which frequently does not take place until nausea is excited. It has been used with success in this malady by Mr. Cline;[1] by Mr. Collins;[2] by Drs. Thomas, Eberle, and Francis;[3] and by Dr. Davy.[4] However, Mr. Lawrence,[5] alluding to Mr. Cline's recommendation of it, observes, "I believe general experience has not led others to place any very great confidence in the use of this remedy." In gleet and leucorrhœa it is sometimes serviceable. I have found it occasionally successful, when given in conjunction with the tincture of cantharides, in the latter stage of gonorrhœa, after a variety of other remedies had failed. In passive hemorrhage from the kidneys, uterus, and bladder, it is likewise employed with benefit.

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[1] Mr. R. Phillips, *Transl. of the Lond. Pharm.*

ADMINISTRATION.—The dose of it is from ten to thirty minims, gradually increased to one or two drachms, and taken in some mild diluent.

ANTIDOTES.—In a case of poisoning by it the treatment should be the same as for the mineral acids (see *ante*, pp. 160 and 360).

142. FERRI AMMONIO-CHLORIDUM.—AMMONIO-CHLORIDE OF IRON.

HISTORY.—This substance, which was known to Basil Valentine, has had various appellations; such as *flores salis ammoniaci martiales*, *ferrum ammoniacale*, or *ferrum ammoniatum*.

PREPARATION.—In the London Pharmacopœia it is directed to be thus prepared:—

Take Sesquioxide of Iron, ℥iij.; Hydrochloric Acid, Oss.; Hydrochlorate of Ammonia, lbijss.; Distilled Water, Oiij. Mix the sesquioxide of iron with the hydrochloric acid in a proper vessel, and digest them in a sand-bath for two hours; afterwards add the hydrochlorate of ammonia, first dissolved in the distilled water; strain and evaporate the liquor. Lastly, rub what remains to powder.

By the mutual reaction of sesquioxide of iron and hydrochloric acid we obtain sesquichloride of iron and water. A small portion of protochloride of iron will be produced if any carbonate of the protoxide of iron be mixed with the sesquioxide. By evaporating the solution thus procured with a solution of hydrochlorate of ammonia, we obtain a mixture of these bodies. There is no reason to believe that any chemical combination takes place.

PROPERTIES.—It is met with in the shops in the form of reddish orange-coloured crystalline grains, having a feeble odour and a styptic saline taste. It is deliquescent, and is soluble in both water and alcohol.

Characteristics.—Rubbed with quicklime or caustic potash, ammonia is evolved. Its solution affords chloride of silver when mixed with the nitrate of silver. It reacts as a persalt of iron.

COMPOSITION.—It is a mechanical mixture of hydrochlorate of ammonia and sesquichloride of iron, in the following proportions:—

	Per Cent.
Sesquichloride of Iron	15
Hydrochlorate of Ammonia	85
Ferri Ammonio-Chloridum, *Ph. L.*	100

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[1] *Med. Records and Researches*, Lond. 1798.

[2] *Med. and Phys. Journ.* xvi. 250.

[3] Eberle's *Treat. on Mat. Med.* ii. 270, 2d ed.

[4] Paris's *Pharmacologia*, ii. 478, 6th ed.

[5] *Lond. Med. Gaz.* vi. 845.

It yields about 7 per cent. of sesquioxide of iron when decomposed by an alkali (Mr. R. Phillips).

The yellow bands sometimes found in cakes of hydrochlorate of ammonia are probably a true chemical compound of sesquichloride of iron and hydrochlorate of ammonia (see *ante*, p. 446).

PURITY.—The *London College* gives the following characters of it:—

Totally soluble in proof spirit and in water. Potash added to the solution throws down sesquioxide of iron; afterwards, when added in excess, it evolves ammonia.—*Ph. Lond.*

PHYSIOLOGICAL EFFECTS.—It produces the general effects of the ferruginous preparations; but, on account of the small and variable quantity of iron present, it is a compound which is of little value. The hydrochlorate of ammonia which it contains, renders it alterative, and in large doses aperient.

USES.—It has been employed as a deobstruent in glandular swellings, in amenorrhœa, and other cases where the preparations of iron are usually employed.

ADMINISTRATION.—It may be given in substance in doses of from four to twelve or more grains.

TINCTURA FERRI AMMONIO-CHLORIDI, L.; *Tincture of Ammonio-Chloridi of iron.* (Ammonio-Chloride of Iron, ℥iv.; Proof Spirit, Oj. M.)—"A fluidounce yields by decomposition 5·8 grains of sesquioxide of iron."[1] It should be expunged from the Pharmacopœia.

143. FERRI IODIDUM.—IODIDE OF IRON.

Formula FeI. *Equivalent Weight* 154.

HISTORY.—We are indebted to Dr. A. T. Thomson for the introduction of this substance into medicine.[2] To distinguish it from other compounds of iodine and iron, it is sometimes termed *protiodide of iron*. Other names for it are *ioduret*, *hydriodate*, or *iodohydrate of iron*.

PREPARATION.—Directions for the preparation of this compound are given both by the London and Edinburgh Colleges.

The *London College* orders of Iodine, ℥vj.; Iron Filings, ℥ij.; Distilled Water, Oivss. Mix the Iodine with four pints of the water, and to these add the Iron. Heat them in a sand-bath, and when the liquor has acquired a greenish colour, pour it off. Wash what remains with the half-pint of water, boiling. Let the mixed and strained liquors evaporate at a heat not exceeding 212° in an iron vessel, that the salt may be dried. Keep it in a well-stoppered vessel, access of light being prevented.

The *Edinburgh College* orders any convenient quantity of Iodine, Iron-wire, and Distilled Water in the proportions for making solution of Iodide of Iron [see *Ferri Iodidi Syrupus*]. Proceed as directed for that process; but before filtering the solution concentrate it to one-sixth of its volume, without removing the excess of iron-wire. Put the filtered liquor quickly in an evaporating basin, along with twelve times its weight of quicklime around the basin, in some convenient apparatus in which it may be shut accurately in a small space not communicating with the general atmosphere. Heat the whole apparatus in a hot air-press, or otherwise, until the water be entirely evaporated; and preserve the dry iodide in small well-closed bottles.

The process adopted by the Edinburgh College is that suggested by Messrs.

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[1] Phillips, *op. cit.*

[2] *Observations on the Preparation and Medicinal Employment of the Ioduret and Hydriodate of Iron*, 1834.

T. and H. Smith,[1] of Edinburgh. More recently[2] they have adopted another and an improved plan, in order more effectually to exclude atmospheric air. "According to our new plan, we make a solution of iodide of iron in a Florence flask, with six drachms of pure iron filings, two ounces and a quarter of iodine, and four and a half ounces of cold distilled water. After boiling till the liquid loses its dark colour, we filter rapidly into another clean flask, and, without delay, place the flask over the flame of a spirit lamp or gas-burner, and evaporate the liquid at a boiling heat. The ebullition may be allowed to proceed with very little attention for a considerable period, but when the liquid passes from a green shade into black, close attention becomes then necessary, as the process now approaches very near to its close.

"We can obtain the compound in two states,—either as a crystallized hydrate, or in an amorphous anhydrous form. To obtain it in the first form, an iron wire or a glass rod must be dipped into the liquid in the flask at short intervals, till, on removal and cooling, the iodide forms a dry and hard crust.

"When the evaporation has reached this point, on removal from the heat the fused iodide crystallizes on cooling. To get the iodide in the anhydrous state, the evaporation must be carried still further. The period for bringing the application of heat to a close can very readily be judged of by occasionally placing a piece of cold glass over the mouth of the flask, and removing the heat when moisture ceases to be condensed on the glass. A pure, anhydrous, spongy protiodide will then be found in the flask, as during the whole operation the flask is filled with a body of steam continually given off by the liquid: the atmospheric air is completely excluded to the very last. We have also proved by the test of starch-paper that no free iodine is given off from the beginning to the end of the process.

"We now remove the iodide by breaking the flask and bruising the compound coarsely in a warm, dry mortar, and enclosing it, without the least delay, in small well-corked bottles. If the process has been correctly managed, the iodide will dissolve in distilled water, giving nearly a colourless solution, or at least one having merely a slightly greenish and not a red tinge. It is not quite correct to term it completely soluble, as there is a minute trace of insoluble matter left, being no doubt produced by a slight decomposition of the iodide occurring during filtration, but this will be in proportion less to the same extent as the care has been greater."

Fine soft iron wire, employed by the Edinburgh College, is to be preferred to the iron filings used by the London College. It should be recently cleaned to free it from all rust.

In this process one equivalent of iodine combines with one equivalent of iron, and forms one equivalent of protiodide of iron.

The exclusion of the air is practised as much as possible during the operation to prevent the formation of sesquioxide of iron and the separation of iodine. $2FeI+3O=Fe^2O^3+2I$. An excess of iron is used by the Edinburgh College to take up any iodine which may be set free by the action of atmospheric oxygen.

PROPERTIES.—By evaporation with as little contact of air as possible, solution of iodide of iron yields green tabular crystals.[3] If the solution be evaporated to dryness, and the residue be moderately heated, this salt is fused, and on cooling becomes an opaque, iron-grey, crystalline mass, with a metallic lustre.

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[1] *Edinb. and Lond. Journal of Medical and Surgical Science*, vol. i.

[2] *Pharmaceutical Journal*, vol. iii. p. 487, 1844.

[3] Mr. R. Phillips, *Translation of the Pharmacopœia*

Iodide of iron has a styptic taste. It is fusible, volatile, very deliquescent, and very soluble in both water and alcohol. By exposure to the air, it undergoes decomposition, and deposits sesquioxide: its solution also undergoes a similar change. The iron of the protiodide, which thus becomes oxidized, parts with its iodine. According to some persons, sesquiodide of iron is formed. $6FeI + 3O = Fe^2O^3 + 2(Fe^2I^3)$. But as the decomposed solution has the odour and flavour of iodine, and yields, on the addition of starch, the blue iodide of starch, it is more probable that it contains free iodine. Mr. Phillips, Jun.[1] has suggested that, by the mutual action of iodide of iron and water, hydriodic acid and protoxide of iron are formed. $FeI + HO = FeO + HI$. The latter absorbs oxygen from the air, and becomes sesquioxide, $2FeO + O = Fe^2O^3$; while the hydriodic acid becoming oxidized under the joint influence of air and light, yields water and free iodine. $HI + O = HO + I$. This explanation is supported by the fact that the hydrated iodide of iron becomes more acid by exposure to the air, and that the addition of iodic acid along with the starch augments the amount of iodide of starch formed, because the iodic decomposes the hydriodic acid. $5HI + IO^5 = 5HO + 5I$ (see *ante*, p. 497).

Whatever be the change, it is important to know that by keeping a coil of iron wire in the solution of protiodide, as suggested by Mr. Squire,[2] no free iodine or sesquiodide of iron is produced, although the liquid may be fully exposed to air and light: sesquioxide of iron is formed, but if the solution be filtered, it is found to contain protiodide only. "A solution of protiodide of iron dissolves iodine abundantly, becoming brown, and possibly containing the sesquiodide, Fe^2I^3, but it is more likely that the iodine is not combined, as it is sensible to the test of starch."[3]

Characteristics.—When heated in the air, it evolves violet vapours of iodine, while the iron attracts oxygen from the air, and is converted into sesquiodide. A solution of protiodide of iron yields with a solution of corrosive sublimate a red precipitate,—$FeI + HgC = HgI + FeCl$; and with ferrocyanide of potassium a bluish-white precipitate.

Composition.—The composition of iodide of iron is as follows:—

	At.	*Eq. Wt.*	*Per Cent.*
Iron	1	28	18·2
Iodine	1	126	81·8
Iodide of Iron	1	154	100·0

	At.	*Eq. Wt.*	*Per Ct.*	*J.D.Smith.*
Iron	1	28	14	14·14
Iodine	1	126	63·3	63·64
Water	5	45	22·7	22·22
Hydrated Iodide of Iron	1	199	100·0	100·00

The iodide of iron of the Pharmacopœia contains, according to Mr. Phillips, five equivalents of water, $FeI,5HO$. Wittstein states that the hydrated iodide contains four equivalents only of water, $FeI,4HO$.

It appears from Mr. Scholefield's statement,[4] that iodide of iron, as prepared by the manufacturing chemist, usually contains only from 10 to 15 per cent. of water; for "if the process of evaporation be discontinued whilst the salt contains 22½ per cent. of water, it will be in so deliquescent a state as to be unavailable, unless for immediate use; whilst, on the other hand, if it be proceeded with until it attain the anhydrous state, the heat employed will occasion decomposition by a liberation of iodine and formation of sesquioxide of iron, in consequence of the slight affinity these bodies possess for each other. The medium course is generally pursued, the manufacturing chemist allowing the salt to retain from 10 to 15 per cent., which is soon increased by exposure to the air, together with a partial decomposition."

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[1] *Pharmaceutical Journal*, vol. iv. p. 19. 1844.

[2] *Annals of Philosophy*, May 1836, p. 79. Also *Pharmaceutical Journal*, vol. i. p. 45, 1843.

[3] Kane, *Elements of Chemistry*, p. 782.

[4] *Pharmaceutical Journal*, vol. i. p. 521, 1842.

PURITY.—It should be perfectly soluble in water. By exposure to the air, it absorbs oxygen and forms sesquioxide.

Emits violet vapours by heat, and sesquioxide of iron remains. When fresh prepared it is totally soluble in water. From this solution, when kept in a badly-stoppered vessel, sesquioxide of iron is very soon precipitated; but with iron wire immersed in it, it may be kept clear in a well-stoppered vessel.—*Ph. Lond.*

Entirely soluble in water, or nearly so; forming a greenish solution.—*Ph. Ed.*

PHYSIOLOGICAL EFFECTS. *a. On Animals.*—Three drachms of iodide of iron were administered to a dog: vomiting and purging were produced, but in three days the animal was well. One drachm dissolved in a drachm of water killed a rabbit in three hours and a half, with the appearance of gradually-increased debility: the stomach was found congested, and its lining membrane decomposed. Forty grains injected into the jugular vein of a dog killed the animal within twelve hours: the symptoms were dilatation of the pupils, staggering, vomiting, and bloody stools.

β. On Man.—In *small and repeated doses* its effects are not very obvious, save that of blackening the stools. It sometimes sharpens the appetite and promotes digestion. It passes out of the system in the urine, and both of its constituents may be detected in this fluid. When it does not purge, it frequently acts as a diuretic. In *full doses*, as ten grains, it on one occasion caused uneasy sensation at the epigastrium, nausea, slight headache, copious black stool, and, in two hours, a larger quantity of urine, containing both iron and iodine.[1] Its medicinal influence on the body seems to be stimulant, hæmatinic, tonic, and alterative or deobstruent. It possesses the combined properties of iron and iodine.

Sesqui-iodide of iron is said to produce the same effects, but to be more active than the iodide.[2]

USES.—Iodide of iron is indicated as a tonic, hæmatinic, and resolvent in cases of debility accompanied with a soft and relaxed condition of the solids, and paleness of the skin. It is especially applicable in scrofulous and strumous affections of the glandular system, in which the use both of iodine and iron is indicated.

In tabes mesenterica, and in swellings of the cervical lymphatic glands, it often proves highly advantageous. In chlorosis, and in atonic amenorrhœa, Dr. Thomson found it serviceable; and his testimony of its good effects has been supported by that of others. Its operation must be promoted by exercise, and an invigorating diet. In secondary syphilis, occurring in debilitated and scrofulous subjects, it is in some cases, according to the testimony of both Dr. Thomson and Ricord,[3] a valuable remedy. The last-mentioned writer[4] employed it in the form of injection (composed of from half a drachm to a drachm of iodide dissolved in eight ounces of water) in blenorrhœas, and in that of lotion in venereal and carious ulcers Dr. Pierquin[4] employed it internally and externally in leucorrhœa and amenorrhœa. It has also been used in incipient cancer and in atonic dyspepsia (Dr. A. T. Thomson).

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[1] Dr. A. T. Thomson, *op. cit.*

[2] *Lond. Med. Gaz.* June 18, 1841.

[3] *Journ. de Pharm.* xxiii. 303.

[4] Quoted by Dierbach, *Die neuesten Entd. in d. Mat. Med.* 2te Ausg.

Administration.—The dose of it is three grains gradually increased to eight or ten, or more. Ricord has given forty grains per day. It may be exhibited in the form of tincture or of aqueous solution, flavoured with a little tincture of orange-peel. It must be remembered that acids, alkalies, and their carbonates, most metallic salts, all vegetable astringents, and many organic solutions, decompose it. Pierquin gave it in chocolate, Bourdeaux wine, distilled water, diluted spirit, or made into lozenges with saffron and sugar. In leucorrhœa and amenorrhœa he employed an ointment (composed of a drachm of iodine to an ounce of lard), by way of friction to the upper part of the thighs.

1. **FERRI IODIDI SYRUPUS**, E.; *Syrup of Iodide of Iron*. (Iodine, dry, 200 grs.; Fine Iron-wire, recently cleaned, 100 grs.; White Sugar, in powder, ℥ivss.; Distilled Water, f℥vj. Boil the iodine, iron, and water together in a glass matrass, at first gently, to avoid the expulsion of iodine vapour, afterwards briskly, until about two fluid-ounces of liquid remain. Filter this quickly, while hot, into a matrass containing the sugar. Dissolve the sugar with a gentle heat, and add distilled water, if necessary, to make up six fluidounces. —Twelve minims contain one grain of iodide of iron.)—Mr. Redwood[1] states that when cane sugar is heated in contact with iodide of iron, it becomes very readily changed into grape sugar; and syrup of iodide of iron, as usually prepared, is very liable to become perfectly solid, in consequence of the crystallization of the grape sugar. To obviate this and other changes which occur in this syrup when heat is used in its preparation, Mr. Hemingway[2] has proposed the following modification of the process:—

Take of iodine, pure and dry, ℥iij., ʒvij., ℈ij.; Iron filings, clean, ℥ij.; Distilled Water q. s. to make f℥xiiss. of the solution. Put the iron filings and half the water into a Wedgwood mortar or a flask, and add the iodine in small quantities at a time, agitating the mixture until it has become colourless; then filter the solution, and wash the iron with the remainder of the water. Keep it in a stoppered bottle, with a coil of iron wire. The liquid is called "*the solution*." Each fluidrachm contains thirty grains of crystallized iodide of iron. When wanted for use pour it off without disturbing the sediment, and pass through a coarse filter.

Take of simple syrup, f℥xv.; the solution of iodide of iron, as above, f℥ij. Gently evaporate the syrup over the fire until it has decreased in weight two ounces *avoirdupois*, then introduce it into a bottle, add the solution of iodide of iron, and shake them together. Repeat the agitation after the syrup has cooled, and keep it in small stoppered bottles. Each fʒj. of the syrup contains rather more than gr. iij. of the dry iodide; or four grains of the crystallized (hydrated) iodide. This syrup is faintly green.

Syrup of iodide of iron is a very convenient preparation for the exhibition of the iodide, as it is not so readily decomposed as an aqueous solution of this salt.[3] In the Edinburgh Pharmacopœia it is described as being "colourless, or pale green; transparent; without sediment, even when exposed to the air." Twelve minims or fifteen drops of the Edinburgh preparation contain one grain of iodide (Christison): each fʒj. contains gr. v. of the crystallized iodide. This preparation, therefore, is somewhat stronger than Mr. Hemingway's.

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[1] *Pharmaceutical Journal*, vol. vi. p. 317, 1847.

[2] *Ibid.* p. 315.

[3] For some observations on the chemical properties of Syrup of Iodide of Iron, see Wackenroder, in the *Pharmaceutisches Central-Blatt. für* 1839, S. 628. See also some remarks on *Ioduretum Ferri Saccharatum*, by Kefner, in *Berlinisches Jahrbuch für die Pharmacie*, Bd. xlii. S. 212, 1839.

The officinal syrup of the Edinburgh College may be given several times a day in doses varying from fifteen drops to a fluidrachm. Larger doses are apt to occasion sickness and even vomiting (Christison). As it is readily decomposed by contact with various substances, as well as by exposure to the air, when it is diluted, it is best to administer it in solution in simple water; but the dilution should not be made long before being used. It is, therefore, better to let the patient dilute it immediately before swallowing it.

2. **PILULÆ FERRI IODIDI**; *Pills of Iodide of Iron.*—Agitate 127 grains of Iodine, ℥ss. of coarse Iron Wire, and 75 minims of Distilled Water, in a strong stoppered ounce phial until the froth becomes white. Pour the fluid upon two drachms of powdered sugar in a mortar, triturate briskly, and add gradually half an ounce of liquorice powder, a drachm and a half of powdered gum, and a drachm of flour. Divide the mass into 141 pills, each of which contains about a quarter of a grain of iodide of iron (Leslie, quoted by Christison).

144. Ferri Pernitras.—Pernitrate of Iron.

Formula $Fe^2O^3,3NO^5$. *Equivalent Weight* 242.

Persesquinitrate of Iron; Ferrum nitricum oxydatum.—Obtained by dissolving iron, sesquioxide of iron, or the hydrated sesquioxide of iron, in nitric acid.

Mr. Kerr,[1] who introduced the use of this compound into medicine, gives the following directions for its preparation:—Take of small chips or pieces of iron-wire, ℥iss.; nitric acid, ℥iij. by measure; water, ℥xxvij.; hydrochloric acid, ʒj. Put the iron into an earthenware vessel, and pour on the nitric acid, previously diluted with fifteen ounces of the water. Set the vessel aside till the whole of the acid has united with the iron; then decant the liquid from the portion of iron which remains undissolved, strain, and filter. Add the hydrochloric acid with the remainder of the water, or with as much of that liquid as shall increase the whole solution to thirty ounces. The process usually requires from nine to twelve hours for its completion. Without the use of the hydrochloric acid the liquid is apt to become turbid in a few weeks.

The solution when rightly made is of a beautiful dark red colour when viewed with transmitted light. Its taste is very astringent.

Its topical effects are those of a very powerful astringent and mild caustic. Mr. Kerr thinks that in addition to an astringent quality it possesses the property of diminishing the irritability and tenderness of the mucous membranes with which it comes in contact. Its remote effects are hæmatinic and tonic, like other chalybeates. Altogether, this preparation resembles in its medicinal properties the sesquichloride of iron.

Mr. Kerr introduced it as a valuable remedy for chronic diarrhœa both in children and adults, and whether accompanied with vomiting or not. With the exception of dysentery, and the diarrhœa which succeeds typhus, he found it useful in almost every case of diarrhœa. He employed it both by the mouth and by the rectum. Dr. Graves[2] has borne testimony to its beneficial effects; as has also Kopp,[3] who states that he gave it with success in many cases which had resisted every approved remedy. Dr. T. C. Adams, of the United States, employed it not only in diarrhœa but also in other mucous discharges, as leucorrhœa, in which disease he conjoined the local use of it with its internal administration. He also used it in aphthous sores and tooth-ache (Dunglison). Dr. J. W. Williams[4] used it with success in the diarrhœa and alvine hemorrhage of typhoid fever.

It seems well adapted for hæmatemesis, hemorrhage from the bowels, and uterine hemorrhage, in pale, feeble, and languid constitutions. In such it may be employed to serve the double purpose of a topical astringent, and a tonic and hæmatinic.

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[1] *Edinb. Med. and Surg. Journ.* vol. xxxvii. p. 99, 1832.

[2] *System of Clinical Medicine*, p. 672, 1843.

[3] *Denkwürdigkeit in der ärztl. Praxis*, Bd. iii. S. 327; also Dunglison, *New Remedies.*

[4] *Boston (United States) Med. and Surg. Journ.* April. 7, 1841.

The dose of it is from ten drops to a fluidrachm. Mr. Kerr gave in some cases a teaspoonful three or four times a day; and he was acquainted with one case in which half an ounce was swallowed with no other effect than a considerable degree of costiveness. It may be given in plain water. Kopp gave it in gruel; but it is probable that it would prove less effective as a topical when administered in gruel than in simple water. To children it may be given in doses of a few drops according to their age. Mr. Kerr employed from nine to twelve drops, in warm water, in the form of enema, for young children. Diluted with water, it has been employed, as an injection, in leucorrhœa and uterine hemorrhage.

145. Ferri Arsenias.—Arseniate of Iron.

Formula $3FeO,AsO^5,6HO$. *Equivalent Weight* 274.

Ferrum oxydulatum arsenicicum; Arseniate of the Protoxide of Iron.—Obtained by adding the arseniate of potash, or of soda, or of ammonia, to a solution of protosulphate of iron. The white precipitate is to be collected, washed, and dried. It is very sparingly soluble in water, and its solution by exposure to the air acquires a greenish colour. Its effects are similar to those of arsenious acid: topically it acts as a caustic. It has been employed both internally and externally. Mr. Carmichael[1] used it externally in ulcerated cancer. He applied from half a drachm to a drachm, as a dressing in cases of extensive ulceration. In about half an hour it excites uneasiness, which continues for several hours, and is followed by swelling, especially when it is used for ulcers of the face: in a few days a slough is formed. The employment of it, like that of other arsenical preparations, requires caution, as the arsenic becomes absorbed. It has been used by Biett[2] in lupus, elephantiasis, psoriasis, chronic eczema, and lichen. The dose of it is from $\frac{1}{16}$th to $\frac{1}{12}$th of a grain in the form of pill. It may be applied externally in the form of ointment composed of from ℈j. to ʒss. of the arseniate to ℥j. of fat.

146. FERRI ACETAS.—ACETATE OF IRON.

Formula $Fe^2O^3,3\bar{A}$. *Equivalent Weight* 233.

HISTORY.—A solution of the sesquioxide of iron in acetic acid has long been known and used in the arts. It constitutes the *iron liquor* of the dyer and calico-printer.

PREPARATION.—The *Dublin College* orders it to be prepared as follows:—

> Take of Carbonate [sesquioxide] of Iron, *one part;* Acetic Acid, *six parts.* Digest during three days, and filter.

PROPERTIES.—It is a deep red liquid, having an acid, chalybeate taste. It reddens litmus.

Characteristics.—When heated, it yields acetic acid. Ferrocyanide of potassium strikes a blue colour with it, infusion of galls a purplish-black.

The acetic acid combines with the sesquioxide, as well as with any protoxide of iron contained in the so-called carbonate, and causes the evolution of carbonic acid.

Much of the sesquioxide, sold as carbonate, of iron of the shops has been calcined: when such is the case, it is unfit for making acetate of iron, as its solubility in acetic acid is thereby diminished.

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[1] *Essay on the Effects of Carbonate and other Preparations of Iron upon Cancer*, pp. 50, 66, 341, 343, et. seq. 1809.

[2] Quoted by Aschenbrenner, *Die neuern Arzneimittel.* 1818.

COMPOSITION.—This liquid is essentially a solution of the *acetate of the sesquioxide of iron*, $Fe^2O^3,3\bar{A}$. But it also contains *acetate of the protoxide of iron*, $FeO,\bar{A}$. The relative proportion of the two acetates depends necessarily on the proportion of the two oxides contained in the carbonate employed. The preparation may be considered as essentially a solution of the acetate of the sesquioxide of iron.

Ellerman's disinfecting fluid[1] contains the acetate of the sesquioxide of iron (see *ante*, p. 779).

The PHYSIOLOGICAL EFFECTS and USES are the same as other ferruginous compounds.—The dose is from ten to twenty-five drops in water.

1. FERRI ACETATIS TINCTURA, D.; *Tincture of Acetate of Iron.* (Acetate of Potash, *two parts*; Sulphate of Iron, *one part*; Rectified Spirit, *twenty-six parts*. Rub together the acetate and sulphate, then dry, and add the spirit. Digest for seven days in a well-stoppered bottle; then pour off the clear liquor, and preserve in a vessel perfectly closed.)—In this process the sulphate of iron is decomposed by the acetate of potash, the products being acetate of iron and sulphate of potash. $FeO,SO^3 + 7HO + KO,\bar{A} = FeO,\bar{A} + KO,SO^3$. The mixture becomes moist owing to the evolution of the water of crystallization of the sulphate of iron. The acetate of iron and the excess of acetate of potash dissolve in the spirit; but the sulphate of potash is insoluble in it. The two acetates are probably in combination, as suggested by Dr. Barker,[2] forming a *ferro-acetate of potash*; for the solution, though containing protoxide of iron, is unchanged by atmospheric oxygen. It is a claret-coloured, perfectly transparent tincture, having a strongly chalybeate taste. Dr Aldridge[3] found that the tincture may be decolorized by adding a solution of sulphate of potash to it: he ascribes this to the acetate of potash being carried down by the precipitating sulphate of potash, leaving uncombined protoacetate of iron in solution. It possesses the usual medicinal properties of a ferruginous compound. It is a very agreeable chalybeate, and was introduced into the Dublin Pharmacopœia by Dr. Perceval.—The dose is from half a fluidrachm to one fluidrachm.

2. TINCTURA ACETATIS FERRI CUM ALCOHOLE, D.; *Tincture of the Acetate of Iron with Alcohol.* (Sulphate of Iron; Acetate of Potash, aa. ℥j.; Alcohol, Oij. [*wine measure*]. Triturate together the sulphate and acetate, then dry them, and, when cold, add the alcohol. Digest in a well-stoppered bottle for twenty-four hours.)—The changes that occur in this, are similar to those described in the preceding preparation. Alcohol is substituted for rectified spirit, by which a stronger and more permanent preparation is obtained. —Dose, from 20 drops to a drachm.

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[1] *Pharmaceutical Journal*, vol. vii. p. 280, 1847.

[2] *Observations on the Dublin Pharmacopœia*, 1830.

[3] *Dublin Journal of Medical Science*, vol. x. 1836.

147. Ferri Lactas.—Lactate of Iron.

Formula $FeO,\bar{L},3HO$. *Equivalent Weight* 144.

Ferrum lacticum; *Lactate of the Protoxide of Iron.*—Obtained by dissolving metallic iron in dilute lactic acid: the solution is to be evaporated so that it may crystallize. Wöhler's process, as given by Dr. Christison,[1] is as follows:—Sprinkle in two pounds of sour whey an ounce of sugar of milk, and the same quantity of pure iron filings. Digest at a temperature of 100° F. until the sugar be dissolved, and then add another portion of sugar of milk. As soon as a whitish crystalline powder begins to form, the solution is strongly enough charged with lactate of iron. Then boil and filter into a close vessel; and the salt is partly deposited on cooling in greenish-white prisms, and partly forms a crystalline crust. These crystals, when slightly washed with cold water and quickly dried with bibulous paper, are pure enough for medical purposes; and they may be obtained quite pure by a second crystallization." The iron dissolves in the free lactic acid with the evolution of hydrogen gas: fresh lactic acid is furnished by the action of caseine (which acts as a ferment) on the sugar of milk. Lactate of iron is a greenish-white salt, in small acicular or prismatic crystals, which have a sweetish chalybeate flavour. They are soluble in 48 parts of cold or 12 parts of boiling water; and they are nearly insoluble in alcohol.

This salt was introduced into the Materia Medica by Gélis and Conté, whose memoir, on this subject, has been favourably reported on to the Académie Royale de Médecine by MM. Bouillaud, Fouquier, and Bally.[2] It was asserted to be superior to every other preparation of iron on the ground that iron after its administration is converted into a lactate by the lactic acid of the gastric juice, and the universal distribution of lactic acid through the body appeared to lend support to these statements. Bouillaud and others have found it useful in anæmia, amenorrhœa, dysmenorrhœa, and other maladies in which the chalybeates are generally found beneficial. It is administered in doses of from two to five grains. It may be given to the extent of half a drachm daily. It has been employed in a great variety of forms,[3] such as pills, *tablettes*, *pastilles*, *dragées*, bread (*iron-bread!*), and chocolate!! I agree with Mialhe[4] in opinion that there is no evidence of its superiority over the citrate or tartrate of iron.

148. Ferri Tannas.—Tannate of Iron.

Formula $F^2O^3,3\overline{Tan}$. *Equivalent Weight* 716.

Ferrum Tannicum.—"To a boiling solution of 90 parts of pure tannic acid, add gradually 440 parts of subcarbonate (sesquioxide) of iron, which has been prepared from pure sulphate of iron and carbonate of soda and dried at a moderate heat. Agitate the solution till the effervescence ceases. Evaporate the mixture at 176° F. in a porcelain vessel, until it becomes thick; then spread it on glass or porcelain to dry in a stove at 95° F."[5] A *tanno-gallate of iron* (ink) is obtained by adding decoction of nutgalls to a solution of a salt of a sesquioxide of iron (as the persulphas). Tannate of iron is blue. According to Wittstein, its formula is $F^2O^3,4\overline{Tan}$. As contained in ink it is usually mixed with a little gallate. Its properties are astringent, hæmatinic, and tonic. Ink is a popular and successful application to ringworm (*herpes circinatus*). Tannate of iron has been panegyrised in chlorosis, though there is no reason to suppose that it is superior to other chalybeates. Trousseau and Pidoux have employed it in the form of syrup (*syrupus ferri tannatis*), which is thus prepared by Béral[1]:—Take of simple syrup, 375 parts; syrup of vinegar, 125 parts; citrate of the magnetic oxide of iron, 10 parts; extract of nutgalls, 4 parts. Mix and form a syrup. This preparation is said to be soluble and tasteless.

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[1] *Dispensatory*, 2d edit. p. 975, 1848.

[2] *Bulletin de l'Academie Royale de Médecine*, 1840; also Mérat, *Supplément au Dict. de Mat. Méd.* p. 294, 1846; and *Brit. and For. Med. Rev.* vol. x. p. 565, 1840.

[3] See the various formulæ for these preparations in Bourchardat's *Nouveau Formulaire magistral*, 3me éd. p. 277, 1845.

[4] *Traité de l'Art de Formuler*, p. 184, 1845.

[5] Benedetti, quoted by Beasley, *Pocket Formulary*.

[6] Buchner's *Repertorium*, Bd. xlv. S. 289, 1847.

149. Ferri Citrates.—Citrates of Iron.

Two citrates of iron have been employed in medicine.

1. Ferri Protocitras; *Protocitrate of Iron; Citrate of the Protoxide of Iron.* $3FeO, \overline{Ci}$; Eq. Wt. ·273.—This is prepared by treating iron filings with citric acid previously dissolved in distilled water. The salt is white and pulverulent, and but slightly soluble. Bourchardat says it is an excellent chalybeate; but it is rarely used. It may be given in doses of from gr. ij. to gr. viij. in the form of pills.

2. Ferri Percitras; *Percitrate of Iron; Citrate of the Sesquioxide of Iron.* $Fe^2O^3, \overline{Ci}, 2HO = 263$?—Obtained by adding about ℥viij. of moist hydrated sesquioxide of iron to a boiling solution of ℥iv. of crystallized citric acid in ℥xvi. of water, adding rather more oxide than the acid will dissolve. When cold, filter, evaporate by a water-bath to a syrupy consistence, spread out on earthenware dishes, and dry with a gentle heat until it separates in scales.[2] Mr. Hemingway[3] found that it contained from 28 to 30 per cent. of sesquioxide. It is found in garnet red scales. It reddens litmus, is very slowly soluble in cold water, but readily soluble in hot water. Its medicinal properties are similar to the other citrates. Dose from gr. ij. to gr. x. in the form of powder, pill, or solution.

Aqua carbonica cum ferri citrate.—Bewley and Evans's chalybeate water is a solution of thirteen grains of citrate of iron in ℥vj. of carbonic acid water flavoured with syrup of orange-peel. Its flavour is very agreeable; but it is apt to excite unpleasant eructations shortly after it has been swallowed.

The *Citrate of the Magnetic Oxide of Iron*,[4] prepared by combining the magnetic oxide with citric acid, is similar in its medicinal properties to the other citrates.

150. AMMONIÆ FERRICO-CITRAS.—FERRIC CITRATE OF AMMONIA.

Formula $3NH^3, 3Fe^2O^3, 2\overline{Ci}$?. *Equivalent Weight* 621 ?.

HISTORY.—In 1831, M. Beral[5] published a formula for the preparation of a citrate of the sesquioxide of iron; but the salt (*ferri percitras*) obtained by this process is acid, and sparingly soluble in water.

According to Mr. Hemingway,[6] M. Beral prepared and sold, under the name of *citrate of iron*, a salt which was neutral and readily soluble in water, and the formula for the preparation of which was different to the one published.

About 1842, a salt purporting to be similar to M. Beral's preparation was introduced into use in England, under the name of *citrate of iron*. This salt I found to contain ammonia; and in the second edition of this work

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[1] *Pharmaceutical Journal*, vol. ii. p. 48, 1842.

[2] Béral, *Pharmaceutical Journal*, vol. i. p. 594, 1842.

[3] *Lond. Med. Gaz.* March 29, 1844, p. 859.

[4] Béral, *Pharmaceutical Journal*, vol. ii. p. 48, 1842.

[5] *Journal de Pharmacie*, vol. xvii. p. 594, 1831.

[6] *London Medical Gazette*, March 15, 1844, p. 83[illegible]

(published in 1842) I called it *ferro-citrate of ammonia,* and stated that its composition was similar to Aikin's ferro-tartrate of ammonia.[1]

This salt is now commonly known in the shops as *ammonio-citrate of iron* (*ferri ammonio-citras*), or the *citrate of iron and ammonia* (*ferri et ammoniæ citras*); but as the iron appears to enter into the composition of the acid or electro-negative ingredient of the salt, the term *ferro-citrate of ammonia,* originally used by me, appears to be more appropriate. But in order to distinguish the ferro-citrate containing the sesquioxide of iron from those ferro-citrates which contain either the deutoxide or protoxide of iron, I have adopted Mr. Hemingway's suggestion,[2] and denominated it the *ferric citrate of ammonia.*

Preparation.—Mr. Redwood[3] gives two processes for the preparation of this salt:—

> Take of crystallized Citric Acid, ℥iv.; Distilled Water, ℥xvj.; Moist Hydrated Peroxide of Iron, about ℥viij.; Solution of Ammonia, q. s. Dissolve the acid in the water in a Wedgwood's dish, heat the solution to boiling, then add the oxide of iron, which should be in slight excess. Continue the heat of a water-bath until no more oxide of iron is dissolved, then allow the solution to cool; add a little distilled water, to facilitate filtration, and filter the solution; add solution of ammonia until it becomes neutral to test paper; evaporate it at the heat of a water-bath to a syrupy consistence; spread it out on earthenware dishes, and dry with a gentle heat. When dry, it will separate from the dishes in scales."

This is Beral's process for the preparation of the citrate of the sesquioxide of iron, but modified by the addition of solution of ammonia.

The second formula for the preparation of this salt given by Mr. Redwood, and which he says is the best, is the following:—

> Take of Crystallized Citric Acid, ℥iv.; Clean iron filings, or small iron nails, ℥ij.; Distilled Water, q. s.; Solution of Ammonia, q. s. Dissolve the citric acid in twenty times its weight of water in a Wedgwood's dish, add the iron, and apply a gentle heat until effervescence ceases, and no more iron is dissolved, renewing the water from time to time as it evaporates; filter the solution, and add solution of ammonia until it is slightly in excess; evaporate by the heat of a water-bath until it acquires a syrupy consistence; then spread it out in thin layers on earthenware dishes, and dry it with a gentle heat. When dry it will separate from the dishes in scales.

This is a modification of Mr. Aikin's process for the preparation of the ferric citrate of ammonia.

Properties.—This salt occurs in thin shiny scales of a beautiful hyacinth red colour when examined by transmitted light. Its taste is sweetish and astringent. It is neutral to litmus, and readily soluble in water. It is nearly insoluble in alcohol.

Characteristics.—Neither ferrocyanide nor ferridcyanide of potassium produce any effect when added to a solution of this salt, unless a few drops of a dilute mineral acid be previously added, when ferrocyanide causes a dark blue precipitate (Prussian blue). If a few grains of the ferric citrate of ammonia be heated in a test tube with liquor potassæ, a copious evolution of ammoniacal gas takes place.

Composition.—As usually found in commerce this salt is probably a compound of *ammonia, sesquioxide of iron, citric acid,* and *water.*

The quantity of sesquioxide of iron contained in it has been variously stated. Mr. Hemingway[1] obtained nearly 36 per cent. of sesquioxide from a sample prepared by himself; but he says that the commercial salt contains on an average only 30 per cent. At my request Mr. Redwood kindly examined five specimens of the ferric citrate of ammonia, and found that they yielded respectively the following per centage quantities of sesquioxide of iron (Fe^2O^3): No. 1, 31; No. 2, 34.3; No. 3, 34.8; No. 4, 34.4; No. 5, 34.5. Nos. 1, 2, and 3 were commercial samples; Nos. 4 and 5 were prepared in the laboratory of the Pharmaceutical Society. No. 1 was a bad specimen; No. 2, not very good; No. 3, very good; Nos. 4 and 5, good. A salt having the composition $3NH^3,3Fe^2O^3,2\overline{Ci},5HO$, would contain 36.036 per cent. of sesquioxide of iron. The same salt in the anhydrous state would yield 38.6 per cent. of sesquioxide.

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[1] *Elements of Materia Medica,* vol. i. p. 868, 2d edit. 1842.

London Medical Gazette, March 29, 1844, p. 863.

Gray's *Supplement to the Pharmacopœias,* 2d edit. 1848.

According to Wittstein,[2] the composition of the ferric citrate is $5(NH^4,O),4Fe^2O^3,6\overline{Ci},18HO$. But the salt which he obtained does not appear to have been identical with that of English commerce, for he says that it was greenish yellow, and by drying lost ammonia and acquired acidity. Moreover, a salt thus constituted would contain barely 20 per cent. of sesquioxide. Haidlen[3] obtained only 10 per cent. of sesquioxide in the ferric citrate.

PHYSIOLOGICAL EFFECTS.—The topical effects of this chalybeate are very slight. It has very little taste, and that by no means disagreeable; and it rarely disagrees with the stomach. Like the other ferruginous salts in which iron is a constituent of the acid part, this has very little astringency.

The general or constitutional effects resemble those caused by other ferruginous compounds (see *ante*, pp. 189 and 758). Compared with the sulphate and sesquichloride I think that, for the quantity of iron which it contains, it is inferior in activity to them (see *ante*, p. 191).

USES.—The great advantages of this preparation, as a chalybeate, are, 1st, its being devoid of any disagreeable flavour, so that it is readily taken by children and delicate persons; 2dly, its being devoid of irritating properties, so that it is not apt to disturb the stomach; 3dly, its being readily soluble in water, and forming a very agreeable solution; 4thly, it may be given in conjunction with the alkaline carbonates, and many other salts often required when chalybeates are administered.

On the other hand it has its disadvantages: 1st, being devoid of astringent properties it is unfitted for those cases in which the chalybeates are resorted to on account of their topical effects (see *ante*, p. 193); 2dly, it appears to me to operate on the general system more slowly and less powerfully as an hæmatinic (see *ante*, p. 188) than the sesquichloride or sulphate. In extreme anæmia from violent hemorrhage, where an immediate and powerful hæmatinic is required, the ferric citrate of ammonia is inferior to the chalybeates just mentioned.

But in ordinary cases of debility requiring a ferruginous tonic, especially where the stomach is irritable, or where the alkaline carbonates are required to be conjoined, and also in the various strumous affections of children, the ferric citrate is a valuable and useful preparation.

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[1] *London Medical Gazette*, March 20, 1844. Mr. Hemingway infers, that the composition of this salt is one equivalent of citrate of iron and one equivalent of citrate of ammonia; but he adopts 116 as the equivalent for citric acid. If we alter his formula to suit the equivalent (165) for citric acid used in the present work, it will be: $3NH^3,3FeO^3,2\overline{Ci}$, as given in the text.

[2] Buchner's *Repertorium*, 2ter Reihe, Bd. xlii. S. 290, 1846.

[3] *Ibid.* Bd. xxxiv. S. 397, 1844.

ADMINISTRATION.—It may be given in doses of from gr. v. to gr. x. dissolved in water, flavoured with syrup of orange peel, or in some bitter infusion, as of gentian or calumba.

151. Ammoniæ Ferrico-Tartras.—Ferric Tartrate of Ammonia.

Formula $NH^3,Fe^2O^3,\overline{T}$?. *Equivalent Weight* 229 ?.

Ammoniæ Ferro-Tartras; Ferro-Tartrate of Ammonia; Tartrate of Iron and Ammonia; Aikin's Ammonio-Tartrate of Iron.—This salt was first employed in medicine by Mr. Aikin.[1]

It may be prepared by adding caustic ammonia to a solution of tartrate of iron (prepared by digesting together, for two or three days, one part of tartaric acid, dissolved in hot water, with two or three parts of iron filings). The green solution thus obtained is to be evaporated to dryness by a gentle heat. Mr. Procter of Philadelphia prepares it by adding hydrated sesquioxide of iron to a solution of bitartrate of ammonia.

It is in the form of shining brittle fragments of a deep red colour, not very unlike pieces of deep-coloured shell-lac. It is very soluble in water. Its taste is strongly saccharine. According to Mr. Hemingway,[6] it contains 34·9 per cent. of sesquioxide of iron.

Its general effects are analogous to those of the other ferruginous compounds, except that it has very little if any astringency. Its advantages over other chalybeates are its ready solubility in water, its palatable taste, and the facility with which it may be mixed with various saline substances, without undergoing decomposition. It contains more oxide of iron than the same quantity of sulphate. The dose for an adult is five or six grains in powder, pill, or solution. It may be exhibited in porter without being detected by the taste. It may be added to the compound decoction of aloes without suffering decomposition.

152. POTASSÆ FERRICO-TARTRAS.—FERRIC TARTRATE OF POTASH.

Formula $2KO,Fe^2O^3,2\overline{T}$. *Equivalent Weight* 438.

HISTORY.—This preparation was first described by Angelus Sala at the commencement of the seventeenth century. Mr. R. Phillips[3] improved its mode of preparation. The late Dr. Birkbeck described its medicinal properties.[4]

This compound has had various appellations; such as *chalybeated tartar* (*tartarus chalybeatus, ferratus,* vel *ferruginosus*), *tartarized iron* (*ferrum tartarizatum*), *tartar of iron* (*ferri tartarum*), *potassio-tartrate of iron* (*ferri potassio-tartras*), *ferro-tartrate of potash* (*potassæ ferro-tartras*), and *tartrate of potash and iron* (*potassæ et ferri tartras*),

PREPARATION.—Soubeiran[5] directs this compound to be thus prepared:—Take of powdered Bitartrate of Potash, *one part;* Distilled Water, *six parts;* Moist Hydrated Sesquioxide of Iron, *as much as may be sufficient.* Digest them, at the temperature of from 120° to 140° F., until the liquor ceases to dissolve a fresh quantity of hydrate; then filter, and evaporate to dryness by a gentle heat.

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[1] *London Medical Gazette,* vol. viii. p. 438.

[2] *Ibid,* March 29, 1844.

[3] *An Experimental Examination of the last edition of the Pharmacopœia Londinensis,* 1811.

[4] *Lond. Med. Rev.* No. xix. July, 1812.

[5] *Nouveau Traité de Pharmacie.* t. ii. p. 447. 2nde éd.

The process of the London College, according to Mr. Phillips,[1] is a modification of that of Soubeiran. It is, however, much more complex.

The *London College* orders of Sesquioxide of Iron, ℥iij.; Hydrochloric Acid, Oss.; Solution of Potash, Oivss., or as much as may be sufficient; Bitartrate of Potash, ℥xiss.; Solution of Sesquicarbonate of Ammonia, Oj., or as much as may be sufficient; Distilled Water, *Cong.* iij. Mix the sesquioxide of iron with the acid, and digest for two hours in a sand-bath. Add to these two gallons of the water, and set aside for an hour: then pour off the supernatant liquor. The solution of potash being added, wash what is precipitated frequently with water, and while moist boil it with the bitartrate of potash, previously mixed with a gallon of the water. If the liquor should be acid when tried by litmus, pour into it solution of sesquicarbonate of ammonia until it is saturated. Lastly, strain the liquor, and with a gentle heat let it evaporate, so that the salt may remain dry.

The *theory* of this process is as follows:—By the reaction of sesquioxide of iron and hydrochloric acid, we obtain water and sesquichloride of iron. $Fe^2O^3 + 3HCl = Fe^2Cl^3 + HO$.

On the addition of caustic potash, the sesquichloride is decomposed, hydrated sesquioxide of iron is precipitated, and chloride of potassium is left in solution. $2(Fe^2Cl^3) + 6KO + 3HO = 2(Fe^2O^3),3HO + 6KCl$.

When the hydrated sesquioxide of iron is boiled with bitartrate of potash, combination takes place, and the ferric tartrate of potash is formed.

The *Edinburgh College* orders of Sulphate of Iron, ℥v.; Bitartrate of Potash, ℥v. and ʒj.; Carbonate of Ammonia in fine powder, a sufficiency. Prepare the Rust of iron from the sulphate as directed under Ferrugo, and without drying. Mix the pulpy mass with four pints of water; add the Bitartrate; boil till the rust of iron is dissolved; let the solution cool; pour off the clear liquid, and add to this the carbonate of ammonia so long as it occasions effervescence. Concentrate the liquid over the vapour-bath to the consistence of a thick extract, or until the residuum becomes on cooling a firm solid; which must be preserved in well-closed vessels.

The explanation of the formation of hydrated sesquioxide of iron (here called *rust*) has been already explained. The theory of the other part of the process is the same as that of the process of the London Pharmacopœia.

The *Dublin College* orders of Iron, drawn into thin wire, *one part;* Bitartrate of Potash, in very subtile powder, *four parts;* Distilled Water, *eight parts*, or as much as may be sufficient. Let them be mixed, and exposed to the air during fifteen days in a wide vessel. Let the mixture, which is to be occasionally stirred, be kept constantly moist by the daily addition of water, taking care that the iron shall not be entirely covered by the water. Lastly, boil the product in a sufficient quantity of water, and let the filtered liquor evaporate to dryness over a water-bath. Let the Tartar of Iron be kept in a well-stopped vessel.

By the united agencies of air and water, the iron is converted into the sesquioxide, which combines with the bitartrate of potash to form the ferric tartrate of potash.

PROPERTIES.—It is an olive-brown inodorous powder, with a styptic inky taste. It reacts on vegetable colours, mildly alkaline. It is slightly deliquescent, probably from the tartrate of potash which it contains. It dissolves in about four times its weight of water, and slightly in alcohol.

Characteristics.—If ferrocyanide of potassium be added to a solution of ferrum tartarizatum, no blue colour is produced; but if a few drops of an acid (as dilute sulphuric acid) be added, Prussian blue is immediately formed. Potash, soda, or their carbonates, do not decompose this solution at ordinary temperatures; nor does ammonia or its carbonates, even by the aid of heat. Tincture of nutgalls causes a dark-coloured precipitate. Sulphuric, nitric, or hydrochloric acid, causes a precipitate which is re-dissolved by an excess of acid; the solution has then a very astringent taste. Tartaric acid causes the formation of crystals of tartar. Heated in a covered crucible, ferric tartrate of potash yields charcoal, carbonate of potash, and protoxide of iron.

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[1] *Translation of the Pharmacopœia.*

COMPOSITION.—The following table exhibits the composition of ferric tartrate of potash, according to Soubeiran and Capitaine,[1] and to Phillips.[2]

The salt obtained by Soubeiran and Capitaine had the following composition:—

	Atoms.	*Eq. Wt.*	*Per Cent.*	*Soubeiran & Capitaine.*
Potash	1	47	18·147	18·23
Sesquioxide of Iron	1	80	30·888	30·49
Tartaric Acid	1	132	50·965	51·28
Tartarized Iron	1	259	100·000	100·00

But the pharmacopœial preparation has, according to Mr. R. Phillips, only 18 per cent. of sesquioxide of iron; and, adopting his analysis, the composition of this salt is as follows:—

	At.	*Eq. Wt.*	*Per Ct.*
Potash	2	94	21·461
Sesquioxide of Iron	1	80	18·265
Tartaric Acid	2	264	60·274
Tartarized Iron	1	438	100·000

or

	At.	*Eq. Wt.*	*Per Ct.*
Neutral Tartrate of Potash	1	226	51·598
Basic Tartrate of the Sesquioxide of Iron	1	212	48·402
	1	438	100·000

As neither ferrocyanide of potassium nor the alkalies produce any precipitate in a solution of this salt, the sesquioxide of iron would appear to be a constituent of the acid, or electro-negative ingredient of the salt. It may be, therefore, regarded as a double salt, composed of basic tartrate of the sesquioxide, as the acid or electro-negative ingredient, and tartrate of potash as the basic or electro-positive ingredient. Geiger[3] regards it as a combination of tartrate of iron and ferrate of potash.

PURITY.—In commerce we frequently meet with an imperfectly prepared compound, in which none or only part of the sesquioxide of iron is in chemical combination with bitartrate of potash. In this state it is only partially soluble in water, and the solution strikes a blue colour with the ferrocyanide of potassium, and throws down a reddish-brown precipitate with solution of potash. The following are the characters of the properly prepared salt:—

Totally soluble in water: the solution does not change either litmus or turmeric: nor is it rendered blue by ferrocyanide of potassium; nor is any thing precipitated from it by any acid or alkali. The magnet does not act upon it.—*Ph. Lond.*

Entirely soluble in cold water: taste feebly chalybeate: the solution is not altered by aqua potassæ, and not precipitated by solution of ferrocyanide of potassium.—*Ph. Ed.*

PHYSIOLOGICAL EFFECTS.—In its effects on the system it agrees, for the most part, with other ferruginous compounds. Its taste, however, is comparatively slight; its astringency is much less than the sulphate or sesquichloride, and consequently its constipating effects are not so obvious; and its stimulating influence over the vascular system is said to be somewhat milder. These peculiarities in its operation are supposed to depend on the tartaric acid and potash with which it is in combination.

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[1] *Journal de Pharmacie*, t. xxv. p. 739, 1839.

[2] *Translation of the Pharmacopœia*, 4th edit. 1841.

[3] *Handb. d. Pharm.*

USES.—It is not frequently employed, yet it is a very eligible preparation of iron, and may be employed wherever the ferruginous tonics are indicated.

ADMINISTRATION.—The dose of it is from ten grains to half a drachm, in the form of solution or bolus, combined with some aromatic.

This salt was formerly employed in medicine, under the name of *globuli martiales* or *boules de Nancy*; they were wrapped in a piece of muslin and suspended in water to form a chalybeate solution.

VINUM FERRI; *Wine of Iron*; *Steel Wine*. In the London Pharmacopœia of 1824 this was ordered to be prepared as follows:—Take of Iron Filings, ℥ij.; Wine [Sherry], Oij. (*wine measure*). Mix and set the mixture by for a month, occasionally shaking it; then filter it through paper.

The iron suffers oxidation by the united influence of air and water, and the oxide of iron thus formed combines with the acids (malic, tartaric, and acetic?) contained in the wine. Mr. Phillips[1] says a pint of this vinum ferri contains 22 grains of sesquioxide of iron.

In the London Pharmacopœia of 1836 the preparation called *vinum ferri* was made without wine! It was prepared with iron, cream of tartar, distilled water and proof spirit. A pint of it contained only 16 grains of sesquioxide of iron. This formula is not followed for the preparation of vinum ferri now kept in the shops.

Vinum ferri is a weak chalybeate; it is sometimes administered to scrofulous and anæmic children, and to other persons. The dose of it is f℥j. to f℥iv., or more.

ORDER XXVIII. COPPER AND ITS COMPOUNDS.

153. CUPRUM.—COPPER.

Symbol Cu. *Equivalent Weight* 32.

HISTORY.—*Cuprum*, or *copper*, received its name from Κύπρος, the island of Cyprus, where it was first discovered, or at least worked to any extent. It seems to have been known in the most remote ages of antiquity, for Moses[2] speaks of brass (an alloy of copper and zinc). The alchymists called it *Venus*, ♀.

NATURAL HISTORY.—It is found in both kingdoms of nature.

α. IN THE INORGANIZED KINGDOM.—Copper is found in the metallic or reguline state (*native copper*); combined with oxygen, both as protoxide, Cu^2O (*red copper ore*), and oxide, CuO (*black copper*); combined with sulphur, as the protosulphuret Cu^2S (*glance copper*), and as sulphuret CuS (*blue* or *indigo-copper*), and also forming double sulphurets (*variegated copper* FeCuS, *copper pyrites* $FeCuS^2$, &c.); combined with selenium; with chlorine (*atacamite* or *muriate of copper*); and with oxygen and an oxyacid (*carbonate, phosphate, sulphate, silicate, vanadiate,* and *arseniate*). It is also found in meteoric iron, in very small quantity, according to Berzelius, in Saidschütz water, and in some earths.

β. IN THE ORGANIZED KINGDOM.—It has been discovered in the ashes of most plants, as of stavesacre, rhatany, flax, nux-vomica, hemlock, &c. Sarzeaux has detected it in the blood of animals.[3]

PREPARATION.—The copper of commerce is usually prepared from *copper*

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[1] *Translation of the Pharmacopœia*, 1824.

[2] *Job*, ch. xxviii.

[3] *Ann. de Chim.* xliv. 334.

pyrites (the double sulphuret of copper and iron). The greater part of the ore raised in Cornwall is of this kind. It is roasted and then smelted, by which *coarse metal* is produced. This is calcined and again smelted, by which we obtain *fine metal*, or, when cast in sand, *blue metal*. By re-roasting and smelting, *coarse copper* is produced. These processes of roasting and smelting effect the expulsion of the sulphur and the oxidizement of the iron. The copper thus produced is melted and exposed to the air, to drive off any volatile matters, by which *blistered copper* is obtained. It is *refined* or *toughened* by melting it and stirring with a birchpole.[1]

PROPERTIES.—It is a brilliant red metal, crystallizable in regular octohedra and cubes, having a specific gravity of 8·86 to 8·894; malleable and ductile: it has a nauseous, styptic taste, and a peculiar and disagreeable smell. It fuses at 1996° F. (Daniell): at a higher temperature it may be volatilized. It is combustible, and is readily oxidated. Acid, alkaline, saline, and fatty bodies, when placed in contact with it in the air, promote its union with oxygen; and, by dissolving a portion of the newly-formed oxide, acquire poisonous properties.

Characteristics.—Copper is easily recognized by its colour, and by its communicating a green tinge to flame. It dissolves in diluted nitric acid; the solution possesses the following properties:—It is blue, or greenish-blue: with potash or soda it yields a blue precipitate (*hydrated oxide of copper*, CuO,HO); a small quantity of ammonia produces with it a similar bluish-white precipitate, but an excess re-dissolves it, forming a deep blue liquid ($2NH^3,CuO,NO^5$); ferrocyanide of potassium occasions in it a reddish-brown precipitate (*ferrocyanide of copper*, $Cu^2,FeCy^3$); sulphuretted hydrogen and the hydrosulphurets throw down a precipitate (*sulphuret of copper*, CuS); and lastly, a polished iron plate plunged into the liquid becomes coated with metallic copper. $CuO,NO^5+Fe=Cu+FeO,NO^5$.

PHYSIOLOGICAL EFFECTS. 1. **Of Metallic Copper.**—Metallic copper appears to produce no pernicious effects when taken internally so long as it retains its metallic state; as many cases are recorded where coins of this metal have been swallowed, and retained for a considerable time, without any ill effects arising; and Drouard[2] gave as much as an ounce of finely-powdered copper to dogs of different ages and sizes, but none of them experienced any inconvenience therefrom.

Notwithstanding these facts, however, various effects have been attributed to it. Thus Cothenius[3] says copper filings operate by stool, urine, and saliva; and the late Professor Barton[4] was accustomed to relate an instance of a child who, having swallowed a cent, continued for some time to discharge several pints of saliva. Lastly, Portal[5] mentions a case in which copper filings, incorporated with crumb of bread, acted powerfully on the system. I have no doubt but that the effects here mentioned arose from the oxidation of the metal by the acids of the alimentary canal.

2. **Of the Cupreous Compounds.** *a. On Vegetables.*—See *Sulphate of Copper.*

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[1] J. H. Vivian, *Ann. of Philosophy*, N.S. vol. v. p. 113.

[2] *Exper. et Observ. sur l'Empoisonnem. par l'Oxide de Cuivre*, Paris, 1802.

[3] Voigtel, *Arzneimittellehre.*

[4] Chapman, *Elem. of Therap.* ii. 457.

[5] Orfila, *Toxicol. Gén.*

β. *On Animals.*—The salts of copper are poisonous to all classes of animals. In large doses they act as caustics and irritants.

In animals killed rapidly by these poisons no morbid appearances are found, in consequence of death being produced by their action on the nervous system; but when the death was slow, marks of gastro-intestinal inflammation, and occasionally indications of inflammation of the brain, have been observed.

γ. *On Man.*—The topical action of the cupreous salts is that of caustics, irritants, and astringents (see *ante*, pp. 157 and 158). On account of their action on sulphuretted hydrogen and the hydrosulphurets, they are applicable as disinfectants (see *ante*, p. 163).

They become absorbed (see *ante*, p. 101). Drouard and others were of opinion that the preparations of copper did not become absorbed, but Lebkuchner (quoted by Christison) has detected copper in the blood of the carotid artery of a cat into whose bronchial tubes he had injected four grains of the ammoniacal sulphate, and Wibmer[1] has found it in the liver of animals to whom he had given the acetate for several weeks.

Most, if not all, the preparations of copper are poisonous in large doses. The sulphuret and ferrocyanide are doubtful exceptions to this statement.

If the cupreous preparations be used in *very small* doses, they sometimes give relief in certain diseases (principally of the nervous system, see *ante*, pp. 185 and 213), without obviously disordering the functions; in other words, in these instances the only apparent effect is the modification observed in the morbid condition. These are the cases in which these preparations have been termed *tonic*, *antispasmodic* or *alterative*, according to the nature of the disease; thus, in ague they have been termed tonic, in epilepsy antispasmodic, in dropsy alterative. The beneficial operation is presumed to be owing to some influence exerted by the remedy over the nervous system.

The effects produced by the long-continued use of small doses of the preparations of copper have not been satisfactorily determined; they are said to be various affections of the nervous system (such as cramps or paralysis), alteration of the colour of the skin, chronic inflammation of the respiratory and digestive apparatus, slow fever, and wasting of the body. These symptoms constitute what has been termed *slow*, or *chronic poisoning by copper*. The smelters or workers in copper do not suffer from the vapour or emanation of this metal, as the workmen employed in the preparation of mercury, of arsenic, or of lead, do, from the vapours of these metals: this, indeed, might be expected, when we consider how much more volatile the latter and their preparations are, than copper and its compounds.

In *larger*, or full medicinal doses, these remedies act as *emetics*, exciting speedy vomiting, with less nausea than tartar emetic produces.

In *still larger* quantities, these bodies act as poisons, giving rise to gastro-intestinal inflammation, and disordering the functions of the nervous system, (especially the cerebro-spinal portion), constituting *acute poisoning by copper*. The usual symptoms are, a coppery taste, eructations, violent vomiting and purging, griping pains, cramps in the legs and thighs, headache, giddiness, convulsions, and insensibility: jaundice is occasionally observed. In some cases the cerebro-spinal symptoms precede those which indicate inflammation of the alimentary canal. In experiments made on animals, it has been observed that death was sometimes produced without any marks of local irritation; the symptoms being those indicative of a disordered condition of the nervous system. By some toxicologists these preparations are ranked among the *irritant* poisons, though Buchner[1], from Reiter's experiments, terms them astringent.

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[1] *Wirk. d. Arzn.* ii. 244.

USES. α. *Of Metallic Copper.*—Copper filings, in doses of three or four grains, were formerly used in rheumatism, and also as an antidote against the effects of the bite of a mad dog.

β. *Of the Cupreous Compounds.*—These preparations are used both as external and as internal remedies: externally as stimulants, astringents, styptics, and caustics; internally, as emetics, tonics or antispasmodics, and astringents. Some of them have also been employed as disinfectants (see *Cupri Sulphas*).

ANTIDOTES.—The chemical antidote for the cupreous preparations is *albumen*; hence, the whites of eggs, and in the absence of these, milk, or even wheaten flour, should be employed. *Iron filings* have been proposed by Navier, by Payen and Chevallier, and subsequently by Dumas and Milne Edwards. The iron decomposes the cupreous salt, and precipitates the copper in the metallic (and, therefore, in an inert) state. The *ferrocyanide of potassium* is also said to be a good antidote: a drachm or two of it may be taken with safety, for it is not so poisonous as was at one time imagined. *Sugar* was proposed by Marcelin Duval as an antidote; its efficacy, though denied by Orfila and Vogel, has been lately reasserted by Postel. The alkaline sulphurets formerly used are worse than useless, since they are active poisons. The inflammatory symptoms are of course to be subdued by the usual means.[2]

154. CUPRI SULPHAS.—SULPHATE OF COPPER.

Formula CuO,SO^3. *Equivalent Weight* 80.

HISTORY.—This substance was probably employed by Hippocrates,[3] under the name of κύανος, to promote the healing of ulcers. Pliny[4] also was doubtless acquainted with it, though he seems to have confounded it with sulphate of iron. His *chalcanthum cyprium* was, perhaps, sulphate of copper. This salt has had various other names; such as *blue vitriol*, (*vitriolum cæruleum*), *Cyprus vitriol* (*vitriolum de Cypro*), *Roman vitriol*, *blue copperas*, *blue stone*, and *bisulphate of copper*.

NATURAL HISTORY.—It occurs in copper mines, as those of Cornwall, &c., and is formed by the joint action of air and water on sulphuret of copper. The cupreous solutions of copper mines are termed *waters of cementation*.

PREPARATION.—It may be prepared by evaporating the water found in, or issuing from, copper mines. It is also produced by roasting copper pyrites, lixiviating the residuum to dissolve the sulphate, and evaporating so as to obtain crystals. In this process both the sulphur and the copper of the pyrites abstract oxygen from the air, and become, the one sulphuric acid, the other oxide of copper: these by their union constitute the sulphate of copper. The sulphate obtained by this process is impure, being contaminated with the sulphate of iron.

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[1] *Toxicologie.*

[2] For further details on this subject, consult the works of Drs. Christison and Taylor.

[3] *De ulceribus*, p. 880, ed. Fœs.

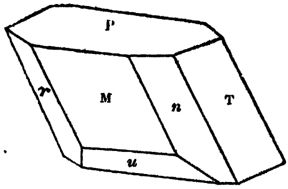
[4] *Hist. Nat.* xxxiv. 32.

Sulphate of copper is "occasionally prepared by dissolving in sulphuric acid an oxichloride of copper, made for the purpose, by exposing sheet copper to the joint action of air and hydrochloric acid."[1] It is also obtained in large quantities in certain processes for refining gold and silver. For the following information respecting its production at the Mint I am indebted to the kindness of Mr. Brande:—

> "A large quantity of sulphate of copper is occasionally obtained here as follows:—When ingots of silver are found to contain a certain quantity of gold, they are melted, granulated, and boiled in sulphuric acid, by which sulphate of copper is formed, and the gold remains in a pulverulent form: the sulphate of silver is then decomposed by the immersion of copper plates; the silver is precipitated in a fine crystalline powder, washed, pressed into masses, and melted, and so affords pure silver, which is afterwards made standard by alloying it with copper, and used for the coinage: the resulting sulphate of copper is then crystallized and sold.
>
> "When gold ingots contain a certain quantity of silver, they undergo a similar process. Suppose a certain number of ingots of gold to contain 2 or 3 per cent. of silver,—instead of leaving it, as formerly, to constitute a part of the standard alloy, it pays to extract it, and substitute copper in its place. To get the silver out of the said ingots they are melted with about 3 parts of silver,—the resulting alloy is granulated and boiled in sulphuric acid,—the gold remains untouched, and all the silver is dissolved and converted into sulphate, which is decomposed by copper as before; so that here again sulphate of copper is obtained."

PROPERTIES.—This salt occurs in fine blue crystals, whose form is the doubly oblique prism. Its sp. gr. is 2·2. It has a styptic, metallic taste, and reacts on litmus as an acid. By exposure to the air it effloresces slightly, and becomes covered with a greenish-white powder. When heated, it loses its water of crystallization, and becomes a white powder (*pulvis sympatheticus*). By a very intense heat it is decomposed, sulphurous acid and oxygen are evolved, and oxide of copper left. It dissolves in about four parts of water at 60°, and two parts of boiling water. It is insoluble in alcohol.

FIG. 139.



Doubly oblique Prism of Sulphate of Copper.

Characteristics.—It is known to be a sulphate by the characteristics for the sulphates (see *ante*, p. 355).

As a salt of the oxide of copper it is characterised by sulphuretted hydrogen causing a black precipitate (CuS), ferrocyanide of potassium a brown precipitate (Cu^2,FeCy), ammonia in excess forming a dark blue colour, and by the action of a polished iron plate (see *ante*, p. 798).

COMPOSITION.—Its composition is as follows:—

	Atoms.	*Eq. Wt.*	*Per Cent.*	*Thomson.*	*Berzelius.*
Oxide of Copper	1	40	32	32	32·13
Sulphuric Acid	1	40	32	32	31·57
Water	5	45	36	36	36·30
Crystallized Sulphate of Copper	1	125	100	100	100·00

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[1] Brande's *Manual of Chemistry*, 5th edit.

Impurity.—The commercial sulphate of copper (*cupri sulphas venalis*) sometimes contains traces of sulphate of iron. It may be detected by excess of ammonia, which throws down the oxide of iron, but dissolves the oxide of copper.

In the air it becomes slightly pulverulent, and of a greenish colour. It is totally soluble in water. Whatever ammonia throws down from this solution an excess of ammonia dissolves.—*Ph. Lond.*

Physiological Effects. α. *On Vegetables.*—It is poisonous to plants:[1] hence its use in preventing dry rot (*Merulius lachrymans*), by soaking timber in it, according to Mr. Margary's patent; and in destroying or preventing the Smut (*Uredo segetum*), or Bunt (*U. caries*), in corn, by immersing the grain in a weak solution of it: the solution is not made sufficiently strong to injure the seed.

β. *On Animals.*—This salt operates as a poison to animals. Six grains killed a dog in half an hour, without producing any appearance of inflammation (Drouard). Applied to a wound it destroyed the animal in twenty-two hours, and the body was every where in a healthy state.[2] Orfila[3] also found that it proved fatal in a few hours when applied to wounds. The only symptoms mentioned are dulness, loss of appetite, and sometimes purging. Inflammation of the mucous membrane of the stomach and rectum was found after death.

γ. *On Man.*—In *very small doses* it has no sensible operation on the body, though it occasionally ameliorates certain diseases, such as epilepsy and ague: in these cases it has been denominated an antispasmodic and tonic (see *ante*, pp. 185 and 213). The local action on the alimentary tube is that of an astringent. Dr. Elliotson[4] has known a patient to take it for three years, for a particular kind of diarrhœa, without any constitutional effect. I have administered six grains thrice a day for several weeks, in an old dysentery, without any other obvious effect than slight nausea and amelioration of the disease for which it was given. In *larger doses* it is a safe and useful emetic, acting very speedily, and without exciting any great disorder of the general system. In *excessive doses* it becomes a poison, producing inflammation of the alimentary canal, and disordering the functions of the nervous system, as noticed when describing the action of the cupreous preparations generally. In a case mentioned by Dr. Percival,[5] two drachms proved fatal; the patient was violently convulsed. In a more recent case[6] there were vomiting and insensibility, but no convulsions or purging: the child died in four hours.

Its topical action is stimulant, astringent, styptic, and caustic. Its causticity depends on its union, either as a neutral or basic salt, with one or more of the constituents of the tissues. Thus it combines with albumen to form a pale bluish green compound, which produces with caustic potash a violet-coloured solution.[7] According to Lassaigne[8] the bluish white precipitate which sulphate of copper occasions in a solution of albumen, is composed of *albumen*

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[1] De Candolle, *Phys. Vég.* 1335.

[2] Duncan, in Christison *On Poisons*, 432.

[3] *Toxicol. Gén.*

[4] *Lond. Med. Gaz.* xii. 557.

[5] *Transactions of the London College of Physicians*, iii. 88.

[6] *Lond. Med. Gaz.* xviii. 624 and 742.

[7] Dr. C. G. Mitscherlich, *Brit. Ann. of Med.* i. 751 and 817, and ii. 51.

[8] *Journ. de Chim. Méd.* t. vi. 2de sér.

90·1, and *sulphate of copper* 9·9. But Mulder regards it as an albuminate of the oxide of copper.

USES.—Where speedy vomiting without much nausea is required, as in cases of narcotic poisoning, sulphate of copper is a tolerably sure and valuable *emetic*. It has also been employed, with success, to provoke vomiting in croup, and thereby to promote the expulsion of the false membrane.[1]

As an *astringent* it has been used with great benefit in chronic diarrhœa and dysentery.[2] It often succeeds where the ordinary vegetable astringents fail. It should be given in doses of from half a grain to two or more grains twice or thrice a day, in combination with opium. I have employed it with most excellent effects in the old diarrhœas of infants, in doses of $\frac{1}{12}$ of a grain. The largest dose I have given to an adult is six grains, as above mentioned. It is also used as an astringent to check excessive secretion from the bronchial and urino-genital mucous membranes. Dr. Wright[3] found it serviceable in dropsy.

As a *tonic* or *antispasmodic* it has been given in intermittent diseases, as the ague; and in some maladies of the nervous system (epilepsy and chorea). In epilepsy it has recently been strongly recommended by Dr. F. Hawkins.[4]

As a *topical* agent, it has often been employed in substance as an application to ulcers, either for the purpose of repressing excessive soft and spongy granulations, commonly denominated "proud flesh," or of hastening the process of cicatrization: and for either of these purposes it is one of the best agents we can employ. Solutions of it are frequently applied to mucous membranes, to diminish excessive secretion; thus to the conjunctiva, in chronic ophthalmia, and the mucous lining of the vagina or urethra, in discharges from these parts. In superficial ulcerations of the mucous membranes (especially of the mouth), one or two applications of the sulphate of copper, in substance, are generally sufficient to heal them.

As a *styptic* a solution of this salt is sometimes used to repress hemorrhages from a number of small vessels. Rademacher applied with good effect brandy impregnated with sulphate of copper in a case of alopecia, or baldness, which occurred in a young man; but this mode of treatment failed in the hands of Dr. T. J. Todd.[5]

It may be used as a deodorizer to destroy the smell of sulphuretted hydrogen, or hydrosulphuret of ammonia, evolved by putrefying substances (see *ante*, p. 163). It acts by forming sulphuret of copper.

ADMINISTRATION.—The dose of it, as an *emetic*, is from three or four grains to fifteen; as an *astringent*, or *tonic*, from a quarter of a grain to one, two, or more grains, given so as not to occasion vomiting. Solutions used for external purposes vary considerably in their strength in different cases, but usually from one or two grains to eight or twelve, dissolved in an ounce of water, are employed.

ANTIDOTES.—See *ante*, pp. 160 and 800.

CUPRUM ALUMINATUM; *Lapis divinus*: *Pierre divine*; *Divine Stone*; *Lapis Ophthalmicus*. (Take of sulphate of copper, nitrate of potash, and alum, of each ℥iij. Having reduced them to powder, heat them in a glazed earthen crucible until they undergo the watery fusion: then add ʒj. of Camphor in powder, mix, and pour out on an oiled slab. When cold, break the mass into pieces, and preserve in a stoppered bottle.) A solution of ʒj. of this substance in 32 fluidounces of water forms the *collyre dit pierre divine*, which is used as an eye wash.

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[1] *Brit. and For. Med. Rev.* i. 568.

[2] Elliotson, *Lond. Med. Gaz.* viii. 878, and xii. 577; also *Med.-Chir. Trans.* xiii. 451.

[3] *Lond. Med. Journ.* i. and x.

[4] *Lond. Med. Gaz.* viii. 183.

[5] *Cyclop. of Pract. Med.* i. 52.

155. AMMONIÆ CUPRO-SULPHAS.—CUPRO-SULPHATE OF AMMONIA.

Formula $NH^3,CuO+NH^3,HO,SO^3$. *Equivalent Weight* 123.

History.—Boerhaave was acquainted with an ammoniacal solution of copper. In 1757, Weissman gave imperfect directions for its preparation. In 1799, Acoluth published a better process. Dr. Cullen introduced this substance into practice in this country. It is usually called *ammoniated* or *ammoniacal copper* (*cuprum ammoniatum*, vel *ammoniacum* seu *ammoniacale*) or *ammoniaret of copper* (*cupri ammoniaretum*). It is also termed the *ammonio-sulphate of copper* (*cupri ammonio sulphas*).

Preparation.—All the British Colleges give directions for its preparation.

The *London College* orders of Sulphate of Copper, ℥j.; Sesquicarbonate of Ammonia, ℥iss. Rub them together until Carbonic Acid ceases to evolve; then dry the Ammonio-sulphate of Copper, wrapped in bibulous paper, in the air.

The directions of the *Edinburgh College* are essentially similar; with the addition that the product is to be preserved "in closely-stoppered bottles."

The *Dublin College* employs of Sulphate of Copper, *two parts*; Carbonate of Ammonia, *three parts*.

The proportions of ingredients employed are about one equivalent of sulphate of copper, and one and a half equivalents of sesquicarbonate of ammonia. When rubbed together, these salts give out part of their water of crystallization, by which the mixture becomes moist; and, at the same time, a portion of the carbonic acid of the sesquicarbonate escapes, producing the effervescence alluded to; and the compound acquires a deep azure-blue colour. This colour is probably owing to cuprate of ammonia; for oxide of copper with caustic ammonia forms a similarly-coloured liquid.

If this view be correct, the decomposition may be thus explained:—An equivalent of hydrated sesquicarbonate of ammonia reacts on one equivalent of crystallized sulphate of copper, and produces one equivalent of cuprate of ammonia, one equivalent of sulphate of ammonia, six equivalents of water, and three equivalents of carbonic acid. $CuO,SO^3,5HO+2NH^3,2HO,3CO^2 = NH^3,CuO+NH^3,HO,SO^3+6HO+3CO^2$. The combined cuprate and sulphate of ammonia represent the crystallized cuprosulphate of ammonia (*cuprum ammoniacale*). The pharmacopœial preparation contains an excess of the sesquicarbonate of ammonia.

Properties.—It has a deep azure-blue colour, a styptic metallic taste, and an ammoniacal odour. It reacts on vegetable colours as an alkali; thus it red [illegible] turmeric, and restores the blue colour of litmus, which has been red- [illegible] n acid. By exposure to the air ammonia is evolved, and a green s [illegible] ft, composed of sulphate of ammonia and carbonate of copper.

To prevent this, therefore, it should be preserved in a well-stoppered bottle. It is soluble in water; but unless excess of sesquicarbonate of ammonia be present, the solution, when much diluted, lets fall a subsulphate of copper. Cuprosulphate of ammonia crystallizes in large, right rhombic prisms, which Dr. Kane[1] considers to be macles.

Characteristics.—Dissolved in water, it forms, with a solution of arsenious acid, a green precipitate of arsenite of copper. By heat all its constituents are dissipated, save the oxide of copper. Boiled with caustic potash a solution of sulphate of potash is obtained, the hydrated oxide of copper is thrown down; and ammonia is disengaged. Sulphuric acid may be recognised in the solution by the barytic salts.

By heat it is converted into oxide of copper, evolving ammonia. Dissolved in water, it changes the colour of turmeric, and solution of arsenious acid renders it of a green colour.—*Ph. Lond.*

COMPOSITION.—The essential part of this compound is the cupro-sulphate of ammonia. This, in the crystalline state, has the following composition:—

	Atoms.	*Eq. Wt.*	*Per Cent.*	*Berzelius.*	*Brandes.*
Ammonia	2	34	27·64	26·40	21·410
Oxide of Copper	1	40	32·52	34·00	33·017
Sulphuric Acid	1	40	32·52	32·25	31·753
Water	1	9	7·32	7·35	13·358
Crystallized Cupro-sulphate of Ammonia	1	123	100·00	100·00	99·538

It is probably a double compound of cuprate of ammonia and sulphate of ammonia, $NH^3,CuO+NH^3,HO,SO^3$.

Ammoniated Copper of the Pharmacopœias usually contains some undecomposed sesquicarbonate (bicarbonate?) of ammonia, and probably some sulphate (subsulphate?) of copper.

PHYSIOLOGICAL EFFECTS.—Its action is, for the most part, similar to sulphate of copper. Wibmer[2] examined its effects on horses and dogs. Four grains dissolved in water, and injected into the veins, killed a dog. The respiration and circulation were quickened by it. In some cases vomiting and purging were produced; weakness, tremblings, and paralysis, indicated its action on the nervous system. Its general effects on man are like those of sulphate of copper, but it is thought to be less disposed to occasion nausea and vomiting. An over-dose, however, readily acts as an emetic. Its action is probably somewhat more stimulant to the general system than the sulphate. It is employed in medicine as a tonic and antispasmodic.

USES.—*Internally*, it has been principally employed in chronic spasmodic affections; such as epilepsy, chorea, hysteria, spasmodic asthma, and cramp of the stomach. In epilepsy it has been much esteemed, and was found useful by Dr. Cullen[3] and other accurate observers; but, like all other remedies for this disease, it frequently fails. It has also been used in ague and dropsy. As a *topical* remedy, a solution of it has been employed as an injection in gonorrhœa and leucorrhœa; and as a collyrium, to remove opacity of the cornea.

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[1] *Elements of Chemistry*, p. 833, Dublin, 1841.

[2] *Wirk. d. Arzneim.* ii. 256.

[3] *Treat. on Mat. Med.*

A solution of gr. xv. in ℥ij. water has been successfully used as a wash in prurigo genitalium.

Administration.—It may be administered internally in doses of from half a grain gradually increased to five or more grains. It is usually exhibited in the form of a pill, rarely in that of solution.

1. **PILULÆ CUPRI AMMONIATI**, E.; *Pills of Ammoniated Copper.* (Ammoniated Copper in fine powder, *one part;* Bread Crumb, *six parts;* Solution of Carbonate of Ammonia, *a sufficiency.* Beat them into a proper mass; and divide it into pills, containing each half a grain of ammoniated copper).—Dose from one to five or six pills in the before-mentioned cases.

2. **LIQUOR CUPRI AMMONIO-SULPHATIS**, L.; *Cupri Ammoniati Solutio,* E.; *Cupri Ammoniati Aqua,* D.; *Solution of Ammoniated Copper; Aqua Sapphirina.* (Ammonio-sulphate of Copper, ℥j.; Distilled Water, Oj. Dissolve the Ammonio-sulphate of copper in the water, and strain. *L. E.*—The *Dublin College* uses of Ammoniated Copper, *one part;* Distilled Water, *one hundred parts*).—This solution is applied to indolent ulcers as a stimulant and detergent; and, when diluted, to the eye, to remove slight specks of the cornea.

156. CUPRI ACETATES.—ACETATES OF COPPER.

Five compounds of oxide of copper and acetic acid are known; of these, three are subsalts, and two are neutral.

Subacetates...	Trisacetate of Copper	$3CuO,\bar{A},2HO$
	Diacetate of Copper, hydrated (*blue verdigris*)	$2CuO,\bar{A},6HO$
	Subsesquiacetate of Copper, crystallized	$3CuO,2\bar{A},6HO$
Acetates	Acetate, crystallized (*crystallized verdigris*)	$CuO,\bar{A},HO$
	Acetate, crystallized, penthydrated	$CuO,\bar{A},5HO$

L. Gmelin enumerates, on the authority of Berzelius, another compound, the formula of which is $48CuO,\bar{A},12HO$.

1. Cupri Subacetates.—Subacetates of Copper.

History.—Hippocrates employed *verdigris,* which he terms χαλκοῦ ἰὸς, or *rust of copper,* in diseases of the eyes, and as an astringent in hemorrhoids.[1] Theophrastus,[2] Dioscorides,[3] and Pliny,[4] describe the method of procuring it. The Romans called it *ærugo.* It is usually termed *diacetate of copper;* but this name is objectionable, since verdigris frequently occurs as a *subsesquiacetate* mixed with the *trisacetate.* I prefer the less precise, though more accurate term, *subacetate of copper,* as it includes all the subacetates composing verdigris.

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[1] *Opera,* Ed. Fœs. 635, 636, and 894.

[2] *De Lapidibus.*

[3] Lib. v. cap. xci.

[4] *Hist. Nat.* xxxiv.

PREPARATION.—At Montpelier it is thus made:—The refuse of grapes is allowed to ferment with sour wine, and is then laid in alternate strata with plates of copper: acetous fermentation takes place, and the metal becomes oxidized by the combined influence of the air and acid. In about fifteen days the plates are covered with the acetate of copper: they are then wetted, and exposed for a month to the air: the acetate absorbs the water, and uniting with more oxide of copper, forms a subacetate, which is scraped off, and packed in leathern sacks for exportation. At Grenoble, verdigris is obtained by sprinkling plates of copper with ready-made vinegar.[1]

In this country it is prepared by exposing thin plates of copper to the action of acetic acid. The method now practised consists in alternating plates of copper with pieces of woollen cloth steeped in acetic acid: they gradually become corroded, and superficially covered with verdigris, which is from time to time removed, and the operation repeated as long as the plate lasts.[2]

French verdigris is imported in sacks, weighing from 25 to 30 pounds.

PROPERTIES.—It occurs in masses or in powder. One variety is of a pale bluish-green colour (*green verdigris*); another is blue (*blue verdigris*). The taste is astringent and metallic; the odour is somewhat similar to, though more disagreeable than, acetic acid. Verdigris is insoluble in alcohol. Water resolves it into a soluble acetate and an insoluble trisacetate.

Characteristics.—When digested with strong sulphuric acid, it evolves acetic acid, which is readily distinguished by its odour. Heated in a glass tube it gives out acetic acid: the residue contains metallic copper. If verdigris be boiled in distilled water, a solution is obtained, which is known to contain copper by its colour, and by the before-mentioned tests for its cupreous compounds (see *ante*, p. 798).

COMPOSITION.—*Blue verdigris* is the hydrated diacetate of copper. *Green verdigris* consists of the subsesquiacetate and the trisacetate.[3] The composition of these salts is as follows:—

	DIACETATE.			SUBSESQUIACETATE.			TRISACETATE.		
	At.	*Eq. Wt.*	*Per Ct.*	*At.*	*Eq. Wt.*	*Per Ct.*	*At.*	*Eq. Wt.*	*Per Ct.*
Oxide of Copper	2	80	43·24	1½	60	43·48	3	120	63·5
Acetic Acid	1	51	27·57	1	51	36·96	1	51	27·0
Water	6	54	29·19	3	27	19·56	2	18	9·5
	1	185	100·00	1	138	100·00	1	189	100·0

PURITY.—The following are the characters of its purity given by the London and Edinburgh Colleges:—

> May be partly dissolved in water, and is almost entirely soluble either in ammonia, or with the assistance of heat, in diluted sulphuric acid.—*Ph. Lond.*
>
> It is dissolved in a great measure by muriatic acid, not above five per cent. of impurity being left.—*Ph. Edin.*

Chalk and sulphate of copper are employed to adulterate verdigris. The first effervesces with the mineral acids. The characteristics of the second have been before pointed out (see *ante*, p. 801).

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[1] Dumas, *Traité de Chim.* v. 169.

[2] Brande's *Manual of Chemistry.*

[3] Berzelius, *Traité de Chimie*, iv. 347 and 349.

PHYSIOLOGICAL EFFECTS.—The action of verdigris on the system is very similar to that of the other preparations of copper: thus, taken in small and repeated doses, it operates on the nervous system, and is called tonic and antispasmodic; in larger doses it acts as an emetic; and, in excessive doses, it is a powerful poison, producing both gastro-enteritis (indicated by vomiting, purging, and pain,) and an affection of the nervous system (marked by insensibility, convulsions, and even tetanus).

USES.—Verdigris, when taken into the stomach, being variable and dangerous in its operation, is never administered internally. It was formerly employed in obstinate syphilis, when mercurials failed.

The *powder* is sometimes employed as an escharotic. It is sprinkled over foul and indolent ulcers, or, when mixed with powdered savin, is applied to destroy venereal warts. When used for the latter purpose it rarely fails.

1. **CUPRI SUBACETAS PRÆPARATUM**, D.; *Prepared Verdigris.* (Let the Subacetate of Copper be triturated into powder, and let the finest parts be separated by the mode directed for the preparation of chalk.)—The object of this process is to obtain a very fine powder. The water, however, effects a chemical change on the verdigris, and converts it into a soluble acetate and an insoluble trisacetate.

2. **LINIMENTUM ÆRUGINIS**, L.; *Oxymel Cupri Subacetatis*, D.; *Mel Ægyptiacum; Unguentum Ægyptiacum; Oxymel Æruginis.* (Verdigris, powdered, ʒj.; Vinegar [distilled, *Dubl.*] fʒvij.; Clarified Honey, ʒxiv. Dissolve the verdigris in the vinegar, and strain the solution through linen; afterwards, the honey being added, boil down to a proper consistence.)—Stimulant, detergent, and slightly escharotic. It is applied by means of a camel's-hair pencil to venereal ulcers of the throat, as well as to other indolent ulcers.—Diluted with water it is employed as a gargle.

By keeping, this preparation undergoes chemical change: the honey becomes coloured, and its crystallizable sugar is converted into uncrystallizable saccharine matter, while the subacetate of copper is reduced to the form of minute granules of metallic copper.[1]

3. **UNGUENTUM CUPRI SUBACETATIS**, D.; *Unguentum Æruginis*, E. *Ointment of Verdigris.* (Prepared Verdigris, ʒss.; Olive Oil, ʒj.; Ointment of White Resin, lb. j. M.—Resinous Ointment, ʒxv.; Verdigris, in fine powder, ʒj. M. *Ph. Ed.*)—Stimulant and mildly escharotic. It is used as an application to foul ulcers, as venereal ulcers of the throat and ulcerated tonsils in scarlatina; it is also employed in ophthalmia tarsi; as a cure for the obstinate forms of ringworm; and as an application to corns.

ANTIDOTES.—See *ante*, p. 800.

2. Cupri Acetas.—Neutral Acetate of Copper.

Formula CuO,$\bar{A}$,HO. *Equivalent Weight* 100.

This salt, commonly termed *distilled* or *crystallized verdigris* (*ærugo crystallisata*), and sometimes *flos æruginis*, is met with in the shops crystallized on sticks. It is included in the list of the materia medica of the Dublin Pharmacopœia. It is usually prepared by dissolving common verdigris in acetic acid, and crystallizing. The crystals are oblique rhombic prisms. They consist of one equivalent of oxide of copper, one equivalent of acetic acid, and one equivalent of water. This salt is completely soluble in water, by which it is distinguished from common verdigris. In most other properties it agrees with the latter. The bluish white precipitate obtained by adding a solution of the neutral acetate of copper to a solution of albumen, consists of *albumen* 90.81, and *di-acetate of copper* 9.19. It is soluble in excess of solution of either acetate of copper or of albumen.[1] It is rarely employed in medicine. Its effects and uses are similar to the subacetates. It formerly served for the preparation of concentrated acetic acid. It is used, also, as a pigment.

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[1] Mr. E. Quekett, *Pharmaceutical Journal*, vol. iv. p. 363, 1845.

ORDER XXIX. MERCURY AND ITS COMPOUNDS.

157. HYDRARGYRUM.—MERCURY OR QUICKSILVER.

Symbol Hg. *Equivalent Weight* 100.[2]

HISTORY.—No mention is made of quicksilver in the Old Testament; nor does Herodotus allude to it. From this we might infer that both the ancient Hebrews and Egyptians were unacquainted with it. But we are told on the authority of an Oriental writer, that the Egyptian magicians, in their attempts to imitate the miracles of Moses, employed wands and cords containing mercury, which, under the influence of the solar heat, imitated the motion of serpents.[3] Both Aristotle and Theophrastus[4] mention Ἄργυρος χυτός (*Argentum liquidum*): and the first of these naturalists says that Dædalus (who is supposed to have lived about 1300 years before Christ) communicated a power of motion to a wooden Venus by pouring quicksilver into it. We are also told that Dædalus was taught this art by the priests of Memphis. Pliny[5] and Dioscorides[6] also speak of mercury, and the latter writer describes the method of obtaining it from cinnabar.

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[1] Lassaigne, *Journ. de Chim. Med.* t. vi. 2de sér. p. 305.

[2] "Considerable difference of opinion has prevailed respecting the equivalent or atomic weight of mercury, arising out of the different views which have been adopted in reference to the constitution of its *oxides*, of which there are two,—a grey and a red, and both of them salifiable. If the grey be considered as a *protoxide*, and the red a *binoxide*, then the number 200 will represent the metal: if, on the other hand, it be assumed that the red oxide be the *protoxide*, and the grey a *suboxide* or *dioxide*, the number 100 must be assumed as the weight of the atom of mercury; and there are strong grounds in favour of the latter view; for the grey oxide is very unstable, and deficient, therefore, in the characters of a true protoxide; whereas the red oxide is comparatively permanent and stable, and it is eminently *basic*, verging even upon alkalinity in its properties; and when, to these considerations, we add the evidence deduced from the connection between the specific heat of mercury and its atomic weight, we are, I think, forced to regard the red oxide of mercury as the protoxide, and notwithstanding the inconvenience that will occasionally ensue in reference to the application of this number to some of the mercurial compounds, to represent the metal by the number 100. (100, Gmelin and Thomson; 101·266, Berzelius; 100·04, Erdmann and Marchand; 101·43, Graham; 102, Gregory)."—Brande's *Manual of Chemistry*, 1848.

[3] D'Herbelot, *Bibliothèque Orient.* art. *Moussa.*

[4] *De Lapidibus.*

[5] *Hist. Nat.* lib. xxxiii.

[6] Lib. v. cap. cx.

Mercury was first employed medicinally by the Arabian physicians Avicenna and Rhazes; but they only ventured to use it externally against vermin and cutaneous diseases. We are indebted to that renowned empiric, Paracelsus, for its administration internally.

SYNONYMES.—The names by which this metal has been distinguished are numerous. Some have reference to its silvery appearance and liquid form: as ὑδράργυρος, *hydrargyrus* and *hydrargyrum* (from ὕδωρ, *aqua*, and ἄργυρος, *silver*); others to its mobility and liquidity, as well as its similarity to silver, such as *argentum vivum*, *aqua argentea*, *aqua metallorum*, and *quicksilver*. It has been called *mercury*, ☿, *mercurius*, after the messenger of the gods, on account of its volatility.

NATURAL HISTORY.—Mercury is comparatively a rare substance. It is found in the metallic state, either pure (*native* or *virgin mercury*), in the form of globules, in the cavities of the other ores of this metal, or combined with silver (*native amalgam*). Sulphuret of mercury (*native cinnabar*) is the most important of the quicksilver ores, since the metal of commerce is chiefly obtained from it. The principal mines of it are those of Idria in Carniola, and Almaden in Spain. The latter yielded 10,000 lbs. of cinnabar annually to Rome in the time of Pliny.[1] Subchloride of mercury (*mercurial horn ore* or *corneous mercury*), iodide of mercury, and seleniuret of mercury, are also found native. Traces of this metal have also been met with in common salt, during its distillation with sulphuric acid, by Rouelle, Proust, Westrumb, and Wurzur.[2]

PREPARATION.—The extraction of quicksilver is very simple. In some places (as in the Palatinate and the Duchy of Deux-Ponts) the native cinnabar is mixed with caustic lime, and distilled in iron retorts. The products are sulphuret of calcium, sulphate of lime, and mercury, which distils over. $4HgS + 4CaO = 3CaS + CaO,SO^3 + 4Hg$. At Almaden the ore is roasted, by which the sulphur is converted into sulphurous acid, and the mercury volatilized $HgS + 2O = Hg + SO^2$. At Idria a modification of this process is followed.[3]

COMMERCE.—Quicksilver is imported in cylindrical, wrought-iron bottles (holding from 60 lbs. to 1 cwt.), the mouth of each being closed by an iron screw; and also in goat-skins, two or three times doubled. The quantities imported in the years 1827, 1830, and 1840, and the places from which the metal was brought in the two first years, are thus stated in the Parliamentary papers[4]:—

	1827.	1830.	1840.
Spain and the Balearic Islands	653,374 lbs.	1,675,652 lbs.	328,566 lbs.
Gibraltar	121,320 "	— "	
Italy and the Italian Islands	108,567 "	331,416 "	
	883'261 "	2,007,068 "	

The iron bottles in which mercury is imported are sometimes used for the preparation of oxygen gas (see *ante*, p. 267).

In 1844 a quantity of quicksilver, of good quality, was imported from

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[1] *Hist. Nat.* xxxiii.

[2] Gmelin, *Handb. d. Chemie*, i. 1282.

[3] Dumas, *Traité de Chimie*, iv. 305.

[4] *Statement of the Imports and Exports* for 1827 and 1830: and *Trade List* for 1840.

China in little bamboo bottles or barrels, covered with cemented linen cloth: each barrel holding about 20 lbs.[1]

PROPERTIES.—At ordinary temperatures quicksilver is an odourless, tasteless, liquid metal, having a whitish colour, like silver or tin. Its sp. gr. is 13.5 or 13.6. When intimately mixed with pulverulent or fatty bodies, it loses its liquid character, and it is then said to be *killed*, *extinguished*, or *mortified*. When cooled down to −38.66° F., it freezes, and crystallizes in needles and regular octohedrons. In this state it is ductile, malleable, and tenacious; and its density is 13.391. At 662° F. it boils, and produces an invisible elastic vapour, whose sp. gr. is 6.976. Mr. Faraday[2] has shown that at common temperatures, and even when the air is present, mercury is always surrounded by a mercurial atmosphere; and, according to Stromeyer, at from 140° F. to 160° F., mercury, when mixed with water, is volatilized in considerable quantities. The presence of lead or tin retards the distillation of mercury, while that of platinum appears to accelerate it.

Characteristics.—In its *metallic* or *reguline* state, mercury is distinguished by its liquidity at common temperatures, and by its volatility. When invisible to the naked eye, and in a finely divided state, it may be readily detected by the white stain (called by workmen *quickening*) communicated to gold and silver. Mercurial vapour may be detected by exposing gold or silver to its influence. If mercury be in combination with other metals, and the tests now mentioned be not applicable, we may dissolve the suspected substance in nitric acid, and proceed as for the mercurial salts.

The *mercurial compounds*, when heated with potash or soda, or their carbonates, yield globules of metallic mercury, which may be recognised by the properties already described. If calomel (Hg^2Cl) be the mercurial compound examined, the changes are as follows:—$Hg^2Cl + NaO,CO^2 = NaCl + Hg^2 + O + CO^2$. Solutions of the mercurial salts, placed for some time in contact with a piece of bright copper, and afterwards rubbed off with paper, leave a silvery stain behind, which disappears when the copper is heated to redness. With nitrate of the suboxide of mercury the changes are as follows:—$Hg^2O,NO^5 + Cu = Hg^2 + CuO,NO^5$. Those compounds which are of themselves insoluble in water may be dissolved by digesting them with nitric acid; and the copper test may then be applied. In this way the mercury contained in calomel, vermilion, sulphate and iodide of mercury, may be readily recognised. Sulphuretted hydrogen produces, with mercurial solutions, a black precipitate (*sulphuret of mercury*, HgS).

Solutions of the *protosalts of mercury* yield, with caustic potash or soda, a grey or black precipitate (*oxide of mercury*, Hg^2O); and, with iodide of potassium, a greenish precipitate (*iodide of mercury*, Hg^2I).

Solutions of the *persalts of mercury* yield, with caustic potash or soda, a yellow or reddish precipitate (*binoxide of mercury*, HgO); and with iodide of potassium, a scarlet one (*biniodide of mercury*, HgI).

PURITY.—The purity of this metal is ascertained by its brilliancy and great mobility. Mechanical impurities—such as adhering dirt or dust—are instantly detected, and may be separated by straining through flannel, or by filtering through a small hole in the apex of an inverted cone of paper. The presence of lead, tin, zinc, or bismuth, may be suspected by the rapidity with which the metal tarnishes in the air, and by its small parts *tailing*, instead of preserving a spherical form. These impurities may be got rid of by distillation in an earthen retort.

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[1] *Pharmaceutical Journal*, vol. iii. p. 539, 1844.

[2] *Quarterly Journal of Science*, x. 354.

Totally dissipated in vapour by heat. Dissolved by diluted nitric acid. When boiled in hydrochloric acid, the acid, when cold, is not coloured, nor is anything precipitated from it by hydrosulphuric acid. Its specific gravity is 13·5.—*Ph. Lond.*

"Entirely sublimed by heat: a globule moved along a sheet of paper leaves no trail: pure sulphuric acid agitated with it evaporates when heated, without leaving any residuum."—*Ph. Ed.*

PHYSIOLOGICAL EFFECTS. 1. **Of Metallic Mercury.** α. *On Vegetables.*—Mercurial vapours are fatal to plants.[1]

β. *On Animals.*—From the experiments of Moulin,[2] Haighton,[3] Viborg,[4] and Gaspard,[5] it appears that when *injected into the veins*, mercury collects in the small vessels of the neighbouring organs, and acts as a mechanical irritant. Thus, if thrown into the jugular vein, peripneumonia is excited; and, on examination after death, little abscesses and tubercles have been found in the lungs, in each of which was a globule of quicksilver as the nucleus.

γ. *On Man.*—Some difference of opinion exists as to the *effects of liquid mercury when swallowed*; one party asserting that it is poisonous, another that it is innocuous. The truth I believe to be this: so long as it retains the metallic state it is inert; but it sometimes combines with oxygen in the alimentary canal, and in this way acquires activity. Avicenna, Fallopius, and Brasavola, declared it harmless; Sue[6] states that a patient took for a long time two pounds daily without injury; and I could refer to the experience of many others who have seen it employed in obstructions of the bowels, without proving noxious; but the fact is so generally known and admitted, as to require no further notice. In some instances, however, it has acted powerfully, more especially where it has been retained in the bowels for a considerable time; no doubt from becoming oxidized. Thus, Zwinger[7] states that four ounces brought on profuse salivation four days after swallowing it. Laborde[8] also tells us, that a man who retained seven ounces in his body for fourteen days was attacked with profuse salivation, ulceration of the mouth, and paralysis of the extremities; and other cases of a similar kind might be quoted.

Dr. Christison considers the question set at rest by the Berlin College of Physicians, and that the metal is innocuous.

Applied externally, liquid mercury has sometimes produced bad effects. Dr. Scheel has related a fatal case, attended with salivation, brought on from wearing at the breast during six years a leathern bag, containing a few drachms of liquid mercury, as a prophylactic for itch and vermin.[9]

The injurious effects of *mercurial vapours*, when inhaled or otherwise applied to the body, have been long known. They are observed in water-gilders, looking-glass silverers, barometer-makers, workmen employed in quicksilver mines, and in others exposed to mercurial emanations. In most instances an affection of the nervous system is brought on, and which is indicated by the *shaking palsy* or *tremblement mercuriel* (*tremor mercurialis*), which is sometimes attended with stammering (*psellismus metallicus*), vertigo, loss of memory, and other cerebral disorders, which frequently terminate fatally. The first symptom of shaking palsy is unsteadiness of the arm, succeeded by a kind of quivering of the muscles, which increases until the movements become of a convulsive character. In all the cases (about five or six in number) which have fallen under my notice, the shaking ceased during sleep. I have not seen the least benefit obtained in confirmed cases by remedial means, although various modes of treatment were tried. This is not in accordance with the experience of Dr. Christison, who says the tremors "are cured easily though slowly." If the individual continue his business, other more dangerous symptoms come on, such as delirium or epilepsy, or apoplexy (*apoplexia mercurialis*); and ultimately death takes place.

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[1] De Candolle, *Phys. Vég.* 1332.

[2] *Philosophical Transactions* for 1691, No. 192.

[3] Beddoes, *On Pulmonary Consumption*, 1799.

[4] Quoted by Wibmer, *Wirkung d. Arzneim.* iii. 88.

[5] Magendie, *Journ. de Physiol.* i.

[6] *Mém. de la Facult. Méd. d'Emulat.* 4th year, p. 252.

[7] *Miscell. Curiosa Decur.* 2nda Ann. 6, 1688.

[8] *Journ. de Méd.* i. 3.

[9] Richter, *Ausführ. Arzneim.* Supplem. Bd. 615.

In some instances, salivation, ulceration of the mouth, and hæmoptysis, are produced by the vapour of mercury. The following remarkable case is an instance in point. In 1810, the Triumph man-of-war, and Phipps schooner, received on board several tons of quicksilver, saved from the wreck of a vessel near Cadiz. In consequence of the rotting of the bags the mercury escaped, and the whole of the crews became more or less affected. In the space of three weeks 200 men were salivated, two died, and all the animals, cats, dogs, sheep, fowls, a canary bird,—nay, even the rats, mice, and cockroaches, were destroyed.[1]

As metallic mercury in the liquid state is not active, it has been thought that mercurial vapour must also be inactive. Thus, Dr. Christison thinks that the activity of the emanations arises from the oxidation of the metal before it is inhaled. I believe, however, with Buchner,[2] Orfila,[3] and others, that metallic mercury, in the finely divided state in which it must exist as vapour, is itself poisonous.

2. Of Mercurial Compounds.—Probably all the mercurial compounds are more or less noxious. The only doubtful exception to this statement is in the case of the sulphurets of this metal, which, according to Orfila,[4] are inert.

α. *Local effects.*—For the most part, the local action of the mercurial compounds may be regarded as alterative, and more or less irritant. Many of the preparations (as corrosive sublimate, the nitrates, &c.) are energetic caustics. The suboxide and calomel are very slightly irritant only: indeed, Mr. Annesley[5] asserts, from his experiments on dogs, and his experience with it in the human subject, that the latter substance is the reverse of an irritant; in other words, that when applied to the gastro-intestinal membrane, it diminishes its vascularity. But I suspect some error of observation here.

β. *Remote effects.*—In *small* and *repeated doses*, the first obvious effect of mercurials is an increased activity in the secreting and exhaling apparatus. This is particularly observed in the digestive organs; the quantity of intestinal mucus, of bile, of saliva, of mucus of the mouth, and probably of pancreatic liquid, being augmented. The alvine discharges become more liquid, and contain a larger proportion of bile. The operation of the medicine does not stop here: the pulmonary, urino-genital, and conjunctival membranes, become moister, the urine is increased in quantity, the catamenial discharge is sometimes brought on, the skin becomes damper, and at the same time warmer; so that mercury seems to promote the excretions generally. The absorbent or lymphatic system seems also to be stimulated to increased activity, for we frequently observe that accumulations of fluids in the shut sacs (as the pleura, the peritoneum, the arachnoid, and synovial membranes) diminish in quantity, and in some cases rapidly disappear, under the use of mercury. At the same time, also, glandular swellings, enlargements, and indurations of various kinds, are dispersed. (For some other observations respecting the *liquefacient* action of mercury, see *ante*, pp. 175 and 184.)

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[1] *Edinb. Med. and Surg. Journ.* xxvi. 29.

[2] *Toxicologie.*

[3] *Toxicol. Gén.*

[4] *Arch. Gén. de Méd.* xix. 330.

[5] *Diseases of India.*

When our object is to obtain the *sialogogue* operation of mercurials, we give them in *somewhat larger doses*. To a certain extent the effects are the same as those already mentioned, but more intense. Of all the secretions, none are so uniformly and remarkably augmented as those of the mucous follicles of the mouth and the salivary glands; and the increased secretion is accompanied with more or less tenderness and inflammation of these parts, the whole constituting what is termed *salivation* or *ptyalism* (*salivatio*, *ptyalismus*, *sialismus*). The first symptoms of this affection are slight tenderness and tumefaction of the gums, which acquire a pale rose colour, except at the edges surrounding the teeth, where they are deep red. Gradually the mouth becomes exceedingly sore, and the tongue much swollen; a coppery taste is perceived, and the breath acquires a remarkable fetidity. The salivary glands soon become tender and swollen; the saliva and mucus of the mouth flow abundantly, sometimes to the extent of several pints in the twenty-four hours. During this state, the fat is rapidly absorbed, and the patient becomes exceedingly emaciated. The blood, when drawn from a vein, puts on the same appearance as it does in inflammatory diseases.

The quantity of saliva and buccal mucus discharged by patients under the influence of mercury, varies according to the quantity of the medicine employed, the susceptibility of the patient, &c. Formerly salivation was carried to a much greater extent than it is at the present day. Thus Boerhaave[1] considered that a patient should spit three or four pounds in twenty-four hours, and Turner[2] says from two to three quarts are "a good and sufficient discharge." Modern experience has shown that all the good effects of mercurials may be gained by a very slight affection of the mouth. Several analyses have been made of saliva from patients under the influence of mercury. Fourcroy, Thomson, Bostock, and Devergie, failed to detect the least trace of mercury in it. But some other persons have been more successful, as will be hereafter mentioned. The following are the constituents of saliva during mercurial ptyalism according to Dr. Thomson[3]:—

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[1] *Aphorismi.*

[2] *Practical Dissertation on the Venereal Disease*, 1737.

[3] *Annal. of Phil.* vi. 397.

Coagulated Albumen	0·257
Mucus, with a little Albumen	0·367
Chloride of Sodium	0·090
Water	99·286
	100·000

It was an opal fluid, having a sp. gr. of 1·0038, and by standing deposited flakes of coagulated albumen. The nitrates of lead and mercury produced copious precipitates with it, but the ferrocyanide of potassium and the infusion of galls had no effect on it. Dr. Bostock[1] found the saliva discharged under the influence of mercury to differ from that of the healthy state in being less viscid, and in containing a substance analogous to coagulated albumen,[2] such as it exists in the serum of the blood; so that it would seem the mercurial action alters the secretion of the salivary glands, and makes it more analogous to the exhaled fluids of the serous membranes.

In Simon's *Animal Chemistry*, several analyses of the saliva from patients under the influence of mercury are given. In all of these there was an increase in the amount of the solid constituents.

I have tested the urine of several patients in a profuse state of salivation without having detected a trace of albumen in it.

The effects of mercury hitherto described are such as are frequently produced for the cure of diseases; but occasionally other phenomena present themselves in individuals who have been subjected to the influence of this metal, and which have been considered as constituting a peculiar malady, to which the name of *mercurial disease* (*morbus mercurialis, hydrargyriasis,* seu *hydrargyrosis, cachexia mercurialis,* &c.) has been given. The *pseudo-syphilis* or *cachexia syphiloidea* of some writers, is supposed to be syphilis more or less modified by the mercurial disease.[3] The following are the ill effects which have been ascribed to this metal, and which Dieterich[4] regards as so many forms of the mercurial disease:—

1. MERCURIAL FEVER (*Febris mercurialis,* Dieter).—Under this name Dieterich has included two febrile states. One of these (*Febris erethica; f. salivosa*) comes on a few days after the use of large doses of mercury, and is characterized by great restlessness, dryness of the mouth, headache, loss of appetite, nausea, hot and dry skin, quick pulse, red gums, swollen tongue, &c.: it usually terminates in a critical discharge (as profuse salivation, purging, or sweating), or an eruption makes its appearance. The affection which Mr. Pearson[5] denominated *mercurial erethism* (*erethismus mercurialis*), is regarded by Dieterich as an adynamic mercurial fever (*febris adynamica*). It is characterized by great depression of strength, a sense of anxiety about the præcordia, frequent sighing, trembling, partial or universal, a small quick pulse, sometimes vomiting, a pale contracted countenance, a sense of coldness; but the tongue is seldom furred, nor are the vital or natural functions much disordered. When these symptoms are present, a sudden and violent exertion of the animal power will occasionally prove fatal.

2. EXCESSIVE SALIVATION (*Ptyalismus stomachalis mercurialis,* Dieter. *Stomatitis*).—I have already noticed mercurial salivation as far as it is ever purposely induced for the

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[1] *Medico-Chirurg. Trans.* xiii. 73.

[2] For some interesting observations on the conversion of albumen into mucus by the action of alkalies and various salts, see Brande, in the *Phil. Trans.* for 1809; Pearson, in ditto, for 1810; Dr. B. G. Babington, in *Guy's Hospital Reports,* vol. ii.; and Dr. G. Bird, in ditto, vol. iii.

[3] See some extraordinary cases of the combined effects of syphilis and mercury, in the *Lancet* for 1832-3, vol. ii. p. 357.

[4] *Die Merkurialkrankheit,* Leipz. 1837.

[5] *Observations on the Effects of various Articles of the Materia Medica,* p. 131, Lond. 1800.

cure of diseases. But it sometimes happens, either from the inordinate employment of mercury, or from some peculiarity in the constitution of the patient, that the mouth becomes violently affected: the gums are tumefied and ulcerated; the tongue is swollen to such an extent that it hangs out of the mouth, incapacitating the patient from either eating or speaking; the salivary glands are enlarged, very painful, and inflamed (*parotitis mercurialis*), and the saliva flows most copiously from the mouth. In one instance sixteen pounds are said to have been evacuated in twenty-four hours. In some cases the gums slough, the teeth loosen and drop out, and occasionally necrosis of the alveolar process takes place. During this time the system becomes extremely debilitated and emaciated; and, if no intermission be given to the use of mercury, involuntary actions of the muscular system come on, and the patient ultimately dies of exhaustion. I have repeatedly seen inflammation and ulceration of the mouth, and profuse salivation, induced by a few grains of calomel or some other mercurial.

A very frequent consequence of excessive mercurial salivation, and the attendant ulceration and sloughing, is contraction of the mucous membrane in the neighbourhood of the anterior arches of the palate, whereby the patient is prevented from opening the mouth, except to a very slight extent. I have met with several such cases. In one case (that of a female) it followed the use of a few grains of blue pill, administered for a liver complaint. The patient remains unable to open her mouth wider than half an inch. Several operations have been performed by different surgeons, and the contracted parts freely divided, but the relief was only temporary. In another instance (that of a child, four years of age) it was produced by a few grains of calomel. Though several years have elapsed since, the patient is obliged to suck his food through the spaces left between the jaws by the loss of the alveolar process.

Non-mercurial salivation.—Salivation is occasionally induced by other medicinal agents, as iodine, iodide of potassium, nitric acid, hydrocyanic acid, arsenious acid, emetic tartar, the preparations of gold, and of copper, foxglove, even opium, and castor oil. Moreover, salivation sometimes arises spontaneously. Of this I have seen more than a dozen cases, mostly females. The greater number of them had not (according to their own account) taken medicine of any kind for several months. Several other cases of it are referred to by Dr. Christison[1] and by Dr. Watson.[2] Occasionally the cause of it is obvious: thus pregnancy, decayed teeth, sore throat, decomposing wool in the ears, &c.; but in many instances it cannot be detected.

It is sometimes a matter of considerable importance to distinguish mercurial from non-mercurial ptyalism. The essential symptoms of salivation from mercury are tumefaction, tenderness, and inflammation of the salivary glands; sponginess, swelling, and inflammation of the gums; copious secretion and excretion of saliva; remarkable fetor of the breath (usually termed mercurial fetor); brassy or coppery taste, and tongue generally swollen. These symptoms may be followed by ulceration and sloughing. But all the same phenomena may exist when no mercury has been taken. Even the so-called mercurial fetor of the breath is not a peculiar effect of this metal.

But the disease which is most likely to be mistaken for the effects of mercury, is gangrene of the mouth, commonly called *cancrum oris*.[3] This usually, but not invariably, occurs in children. It consists of ulceration, followed by gangrene, of the inside of the cheek or lips, and is attended with a copious secretion of offensive saliva. Mercurial ptyalism may sometimes be distinguished from cancrum oris by the peculiar odour of the breath and the salivation preceding the ulceration and sloughing; and by the gums, salivary glands, and tongue, being tumefied and inflamed. But these symptoms are by no means to be relied on, as they may also attend cancrum oris; and it must be admitted, therefore, that the two affections closely resemble each other.[4] The following is a remarkable case of gangrene of the mouth occurring in the adult, and simulating the effects of mercury:—

A man affected with rheumatism, sent to a surgeon for advice, who, without seeing him, prescribed some pills, one of which was to be taken thrice daily. At the end of the week, his rheumatism not being relieved, he sent his wife again to the surgeon, who ordered the pills to be repeated. Another week elapsed, when the patient requested Mr. W. H. Coward, surgeon, of the New North Road, Hoxton, to see him; to whom I am indebted for part of the particulars of this case. Mr. Coward found his patient with the following symptoms: fever, great prostration of strength, sore throat, rheumatic pains in the wrists, profuse ptyalism, more than a pint of saliva being discharged per hour, with the breath having the "mercurial" odour; and on the inner surface of the right cheek a foul ulcer. He ascribed his present condition to the pills, as he had no sore mouth until after taking them. On cutting one of the pills, it was observed to have a light-brown colour, and the odour of opium: hence it was supposed that they were composed of calomel and opium. Purgatives, tonics, and gargles of chloride of soda, were used without avail; and, after some days, Mr. Coward requested me to see the patient. I found him in the following condition: right side of the face swollen and slightly red; gums swollen, red, and ulcerated; breath horribly offensive, its odour not distinguishable from that called mercurial. On the inner side of the cheek, near the orifice of the parotid duct, there was a slough about the size of a sixpenny piece; salivation most profuse,—in fact the saliva flowed in a continued stream from his mouth; over the body were observed a few petechia. Notwithstanding the means employed, the man became worse, the sloughing gradually increased until the whole of the right cheek became involved, and in about a week from my first visiting him he died.

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[1] *Treatise on Poisons*, 3d edit. p. 380.

[2] *London Medical Gazette*, Aug. 6, 1841.

[3] See an excellent account of this disease, by Dr. H. Green, in Costello's *Cyclopædia of Practical Surgery*, vol. i.

[4] In the *London Medical Gazette*, Aug. 28, 1840, is the report of an inquest held on the body of a child who died of cancrum oris, but whose death was alleged to have been caused by mercury.

A day or two before his death, I ascertained from the surgeon who had prescribed the pills that they contained Dover's powder, and not an atom of any mercurial preparation.

3. MERCURIAL PURGING (*Diarrhœa mercurialis*).—Violent purging is a very frequent consequence of the use of mercury. It is frequently attended with griping, and sometimes with sanguineous evacuations. In some cases there is fulness of the left hypochondrium, burning pain and tenderness of the region of the pancreas, and the evacuations are frothy, whitish, tough, and often greenish, at least in the commencement, from the intermixed bile. These symptoms may fairly be referred to an affection of the pancreas analogous to that of the salivary glands. Dieterich[1] terms it *ptyalismus pancreaticus mercurialis* (*diarrhœa salivalis, sialorrhœa alvina, ptyalismus abdominalis*).

4. UROBRHŒA MERCURIALIS.—Excessive secretion of urine, from the use of mercury, is very rare. Two cases are recorded by Schlichting.[2]

5. HIDROSIS MERCURIALIS.—Profuse sweating is another occasional effect of mercury.

6. SKIN DISEASES.—Several forms of skin diseases, both acute and chronic, have been regarded as part of the ill effects of mercury.

α. Eczema mercuriale, Pearson; (*Erythema mercuriale*, Spens and Mullins; *Lepra mercurialis*, Stokes and Moriarty; *Hydrargyria*, Alley, Rayer; *Erysipelas mercuriale*, Cullerier, Lagneau; *Spilosis mercurialis*, Schmalz).—This disease appears occasionally during the progress of a mercurial course. Some writers have frequently met with it: thus, Alley[3] saw forty-three cases in ten years, and of this number eight terminated fatally. Rayer confesses, that in twenty years he never saw but three instances of it. I have seen only two cases of it. The disease consists of innumerable, minute, and pellucid vesicles, which have been mistaken for papulæ. These give the appearance of a diffused redness to the skin, and a sensation of roughness to the touch. Sometimes it is preceded and attended by febrile disorder. In two or three days the vesicles attain the size of a pin's head, and the included serum becomes opake and milky. It soon extends over the body, and is accompanied by tumefaction, tenderness, and itching. It usually terminates by desquamation; but in some cases a copious discharge takes place from the excoriated and tender surface; and when this ceases, the epidermis comes off in large flakes: in some instances the hair and nails fall off, and the eyes and eyebrows become entirely denuded. There is usually some affection of the respiratory organs, indicated by dry cough and tightness of the præcordia.

β. Miliaria mercurialis.—A miliary eruption has been observed by both Peter Frank and Dieterich, apparently as a consequence of the use of mercury.

γ. Chronic skin diseases (*Herpes, Psydracia,* and *Impetigo*).—These are doubtful consequences of the use of mercury. They have occurred after the employment of this metal;

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[1] *Op. cit.*

[2] *Ephemerid*, A. C. L., Nuremburgæ, 1748, t. viii. Obs. viii. p. 25, quoted by Dietcrich, *op. cit.*

[3] *Observ. on the Hydrargyria*, 1810.

but considerable doubt exists as to whether they ought to be regarded as the effect of the remedy, or of the disease for which they have been exhibited, or of some other condition of system. *Herpes præputialis* has been ascribed, by Mr. Pearson, to the previous use of mercury,[1] and his opinion has been adopted by Dieterich;[2] but it certainly now and then occurs when no mercury has been exhibited. The *Psydracia mercurialis* and *Impetigo mercurialis* of Dieterich are still more doubtful effects of mercury.

7. **INFLAMMATION OR CONGESTION OF THE EYE, FAUCES, AND PERIOSTEUM**, have been ascribed by some writers to the use of mercury; but by others the power of this agent to produce these diseases is denied. That they have followed the use of mercury cannot be doubted, but *post hoc* is not *ergo propter hoc*. Dieterich regards the maladies referred to as states of congestion, not of inflammation; and, therefore, calls them *Symphoreses* (from *συμφόρησις, an accumulation*, or *bringing together*).

The inflammation of the conjunctiva (*conjunctivitis mercurialis; symphoreses conjunctivæ oculi mercurialis*, Dieterich), ascribed by Von Ammon[3] to the use of mercury, should probably be referred to some other cause. He says it is characterized by a lilac tint around the cornea; that it sometimes precedes salivation, disappearing when this is established, and is commonly regarded as a catarrhal symptom.

The mercurial iritis (*iritis mercurialis; symphoresis ireos mercurialis*, Dieterich; *iritis rheumatico-mercurialis*, Jaeger), described by Mr. Travers,[4] was, in all probability, an iritis arising from some other cause than mercury.[5]

The so-called mercurial retinitis (*symphoresis retinæ oculi mercurialis*, Dieterich) may be explained in the same way.

An inflammation of the fauces sometimes occurs after the use of mercury (*angina mercurialis; symphoresis faucium mercurialis*, Dieterich). It may come on in five or six days after the use of mercury, and assume an acute form, with a tendency to slough;[6] or it may appear after the employment of mercury for five or six weeks, and take on a chronic form.[7]

Inflammation of the bone or periosteum, and the consequent production of nodes (*symphoresis periostei mercurialis*, Dieterich), has been ascribed to mercury. But the disease is rarely or never seen after the use of this mineral, except when it has been given for the cure of a venereal affection, to which, in fact, it ought with more propriety to be referred.[8]

8. **HYPERTROPHIES** (*Hypertrophiæ*, Dieterich).—Enlargement of the inguinal, axillary, and mesenteric glands (*adenophyma inguinale mercuriale; ad. axillare merc.; ad. miseraicum merc.* Dieterich), as well as of some of the secreting glands, viz. the parotid glands, the pancreas, the testicles, and liver (*adenophyma parotideum merc.; ad. pancreaticum merc.; ad. testiculi merc.; hepatophyma merc.*), and condyloma and ganglion (*condyloma et ganglion mercuriale*, Dieterich) have been ascribed by some[9] to the use of mercury, but, as I believe, on insufficient grounds.

9. **ULCERATION AND SLOUGHING.**—Ulceration of the mouth is a well-known effect of mercury. Ulceration of the throat is likewise a consequence of the use of this mineral (*mercurial ulcerated throat*, Mathias; *mercurial sore throat*, Bacot[10]). Sloughing of the same parts may also be induced. It is well known that venereal sores (especially those called phagedenic) at times assume a sloughing disposition, in consequence of the improper use of mercury.[11] Ulceration of the fibrous membranes (*ulcus membranæ fibrosæ mercuriale*) and absorbent glands (*ulcus glandulorum mercuriale*) has been ascribed to the use of mercury.[12]

10. **NEUROSES MERCURIALES.**—Various symptoms, indicating a disordered condition of the nervous system, are met with in persons who have been exposed to the baneful

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[1] Bateman, *Pract. Synopsis of Cutaneous Diseases*, 6th edit.

[2] *Op. cit.*

[3] *Rust's Magazine*, 1830.

[4] *Surgical Essays*, i. 59.

[5] Mackenzie, *On Diseases of the Eye*, 2d edit. p. 496.

[6] Colles, *Pract. Observ. on the Venereal Disease*, p. 45.

[7] Dieterich, *op. cit.* 273.

[8] Mr. Lawrence, *Lectures on Surgery*, in *Lond. Med. Gaz.* v. 805; Colles, *op. cit.* p. 189.

[9] Mathias, *op. cit.*; and Dieterich, *op. cit.*

[10] *Lond. Med. Gaz.* iii. 312.

[11] Sir A. Cooper, *Lectures on Surgery*, in *Lancet*, iv. 420; Carmichael, *On Venereal Diseases*, p. 165 et seq. 2d edit.

[12] Dieterich, *op. cit.* p. 376.

influence of mercury: such as wandering pains (*neuralgia mercurialis*); a tremulous condition of the muscular system (*tremor mercurialis*), sometimes accompanied with stammering (*psellismus metallicus*), and occasionally terminating in paralysis (*paralysis mercurialis*), epilepsy or apoplexy (*apoplexia mercurialis*). To these Dieterich adds asthma (*asthma mercurialis*), of which he only saw one case, amaurosis (*amaurosis mercurialis*), and hypochondriasis (*hypochondriasis mercurialis*).

Of these, the best known is the shaking palsy (*tremor mercurialis; tremblement mercuriel*), a remarkable affection, which has been already noticed. (See *ante*, p. 813.)

11. CACHEXIA. (*Cachexia mercurialis*).—This condition is characterized by disorder of the digestive organs, loss of appetite, wasting, incapability of much exertion, with increased secretion from all the organs, especially from the salivary glands.[1]

The foregoing are the most important of the ill effects ascribed to the use of mercury. As I have already stated, some of them ought probably to be referred to other causes, and not to the use of this mineral; but as doubt must necessarily be entertained on this point, I have thought it more advisable to mention them. The student will find some pertinent observations concerning them, in a paper by Dr. Musgrave,[2] and in Dr. Currie's pamphlet.[3]

In excessive doses: acute poisoning.—When *large doses* of some of the soluble salts of mercury have been swallowed, *gastro-enteritis* is produced. The patient complains of an acrid styptic taste in the mouth, a feeling of burning and tightness in the throat; the face is usually flushed and sometimes swelled, violent vomiting and purging (frequently of bloody matters) soon come on, the vomiting being increased by every thing taken into the stomach; oftentimes there is irritation of the urinary passages, and sometimes even suppression of the urine; the pulse is small, frequent, and contracted; the respiration difficult; the extremities cold. In some cases *salivation* is produced; this seldom comes on during the first 24 hours, and is seldom delayed beyond the fourth day. Towards the termination of the case, some *disorder of the cerebro-spinal system* come on, such as slight drowsiness or stupor, or even coma; tremors and twitchings of the muscles, and sometimes even violent convulsions; in some cases paraplegia. These symptoms terminate in death. Post-mortem examination discovers inflammation (and its consequences) of the gastro-intestinal membrane.

THEORY OF THE ACTION OF MERCURY.—There are many disputed points connected with the action of mercurials, which it will be convenient to examine under this head.

1. *Absorption of mercury.*—By the external or internal use of mercury this metal becomes absorbed, and is subsequently either deposited in some of the solids of the body, or thrown out of the system by some of the excretories.[4]

The accuracy of this statement is proved by the following facts:—

a. Mercury has been detected in the blood by Zeller, Buchner, Schubarth,[5] Colson,[6] and Dieterich. It appears to be in such intimate combination with this vital fluid that it cannot be recognised by the ordinary tests. Destructive distillation is, in most cases, necessary for its detection.

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[1] Mr. Travers (*Further Inquiry concerning Constitutional Irritation*, p. 87) says, mercurial cachexia is characterized "by irritable circulation, extreme pallor and emaciation, an acute and rapid hectic, and an almost invariable termination in phthisis."

[2] *Edinb. Med. and Surg. Journal*, vol. xxviii.

[3] *Examination of the Prejudice commonly entertained against Mercury.*

[4] Oesterlen has shewn that the globules of mercury contained in mercurial ointment become absorbed, and he has detected them in the viscera and secretions. He also detected globules of the metal in the secretions after the use of calomel (Wunderlich und Roser's *Archiv*, ii. 4. Quoted by Dr. Buchheim).

[5] Quoted by Dr. Christison, *On Poisons*, 3d edit. p. 366.

[6] *Arch. Gén.* xii. 68.

β. *Mercury has been found in the secretions,* viz., in the perspiration, the saliva, the gastro-intestinal secretion, the bile, the urine, and the fluid of ulcers.[1] The blackening of the skin, mentioned both by Harrold[2] and Rigby,[3] as having occurred in consequence of the use of mercury subsequent to the employment of sulphur, establishes the existence of mercury in the cutaneous transpiration. The sulphur and the mercury were thrown out of the system by the skin, and immediately they were out of the sphere of the vital powers they entered into union and formed the black sulphuret of mercury, which was deposited on the integument in a pulverulent form.

γ. *Mercury has been found in the reguline state in the organic solids,* viz., in the bones, brain, synovial capsules, the pleura, the humours of the eye, the cellular tissue, the lungs, &c.[4] In what part of the system reduction is effected, has not been made out.

2. *The constitutional effects of mercury are consequences of its absorption.* For, in the *first* place, mercurials affect the general system to whatever part of the body they may be applied, whether to the mucous membranes, the cutaneous system, or the cellular tissue, or injected into the veins. *Secondly,* the action of mercurials on the system is promoted by agents which augment absorption, and is checked by those which diminish absorption.

3. *After absorption, mercury effects changes in the qualities of the blood, and in the action of the whole organization, but especially the apparatus of organic life.*—Soon after salivation has been established, the blood exhibits an inflammatory crust. At a later period its colour deepens, and its coagulability is diminished; the portion of clot, and therefore of fibrin, to serum becomes smaller. "The formation of albumen and mucus," says Dieterich,[5] "sinks to that of serum; the whole organic formation of the patient is less consistent and cohesive." The same authority also tells us, that under the influence of mercury the electrical condition of the blood changes from the negative (healthy) state to that of positive. According to Dr. Farre,[6] it diminishes the number of red globules of the blood. The evacuations from all the secreting and exhaling organs, especially from the mucous follicles and salivary glands, is much increased. The secretion of bile is also promoted. Dr. Wilson Philip[7] says, "mercury has a specific operation on the liver,—a power not merely of exciting its functions, but of correcting the various derangements of that function in a way which it does not possess with respect to any other organ, and which no other medicine possesses with respect to the liver." I confess I am not acquainted with any facts warranting this broad assertion. The purgative effects of mercury arise partly from the increased secretion of bile, and partly from the stimulus given to the mucous lining of the alimentary tube; more particularly to its follicular apparatus. The *nervous system* appears also to be specifically affected by

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[1] Christison, Colson, and Dieterich, *op. cit.*

[2] *Meckel's Archiv,* iii. 532.

[3] *Lond. Med. Rep.* April 1837.

[4] Christison, *op. cit.;* Wibmer, *Wirkung d. Arzneim.* iii. 85; Colson and Dieterich, *op. cit.*

[5] *Op. cit.* 80.

[6] Ferguson's *Essays on the Diseases of Women,* part i. p. 216.—"A full plethoric woman, of a purple red complexion, consulted me," says Dr. Farre, "for hæmorrhage from the stomach, depending on engorgement, without organic disease. I gave her mercury, and in six weeks blanched her as white as a lily."

[7] *On the Influence of Minute Doses of Mercury,* p. 14.

mercurials. This is to be inferred partly from the effects produced in those who are subjected to the vapours of this metal, such as the shaking palsy, &c. and partly from the effects of the soluble salts, when given in enormous doses. The *heart* and *lungs* are, in some cases, remarkably affected. This was particularly observed by Sir Benjamin Brodie[1] in his experiments on animals with corrosive sublimate; as also by Smith, Orfila, and Gaspard. The affection of the *urinary organs* in poisoning by corrosive sublimate is also not to be overlooked.

4. *The nature of the influence exercised by mercury over the organism* has been a fertile source of discussion. One class of writers has regarded it as mechanical, a second as chemical, a third as dynamical.

α. *Mechanical hypothesis.*—Astruc[2] and Barry[3] fancied that mercury acted by its weight, its divisibility, and its mobility; and thus getting into the blood, separated its globules, rendered it more fluid and fit for secretion, made the lymph thinner, and overcame any existing obstructions.

β. *Chemical hypotheses.*—Some have advocated the chemical operation of mercurials, and have endeavoured to explain their curative powers in the venereal disease by reference to their chemical properties, but without success. Thus Mitié, Pressevin,[4] and Swediaur,[5] assumed that mercury acted chemically on the syphilitic poison, as acids and alkalies do on each other; while Girtanner[6] supposed that the efficacy of mercurials depended on the oxygen they contain. To both hypotheses the same objection applies: if they were true, the larger the quantity of mercury used, the more effectually would the venereal disease be cured. Now this is not found to be the case. Dr. Cullen[7] endeavoured to account for the action of mercury on the salivary glands, in preference to other organs, by assuming that it has a particular disposition to unite with ammoniacal salts, with which it passes off by the various excretions: and as the saliva was supposed to contain more of these salts than other secretions, he thus accounted for the larger quantity of mercury which passed off by these glands, and which, being in this way applied to the excretories, occasioned salivation. But the whole hypothesis falls to the ground when it is known that mercury has no "particular disposition" to unite with ammoniacal salts; and that, even if it had, other secretions are as abundantly supplied with these salts as the saliva. Dr. John Murray substituted another hypothesis, but equally objectionable: mercury, says he, cannot pass off by the urine, because of the phosphoric acid contained in this fluid, and which would form, with the mercury, an insoluble compound. It must, therefore, be thrown out of the system by other secretions, particularly by the saliva, which facilitates this transmission by the affinity which the muriatic acid, the soda, and the ammonia of the secretion, have for the oxide of mercury, and by which a compound soluble in water is formed. The answer to this hypothesis is, that mercury *is* thrown out of the system by the urine, and probably in larger quantity than by the saliva; secondly, the saliva also contains phosphatic salts, according to Tiedemann and Gmelin.

γ. *Dynamical hypothesis.*—Some writers have principally directed their attention to the quality of the effects induced by mercury, and have termed this mineral stimulant, sedative, both stimulant and sedative, tonic or alterative. Those who assume mercury to be a *stimulant* or *excitant* are not agreed as to whether one or more parts or the whole system are stimulated, and if particular parts, what these are. Thus Hecker fixes on the lymphatic system, Schone on the arterial capillary system, Reil on the nerves.[8] The simple answer to all of them is, that other stimulants are not capable of producing the same effects on the constitution as mercury; nay, are frequently hurtful in the very cases in which this metal is beneficial.

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[1] *Phil. Trans.* for 1812.
[2] *De Morb. Ven.* ii. 149.
[3] *Medical Transactions*, i. 25.
[4] Quoted by Richter, *Ausführ. Arzneim.* iv. 305.
[5] *Practical Observations on Venereal Complaints.*
[6] *Abhandl. ü. d. Vener. Krankh.*
[7] *Treat. of the Mat. Med.* ii. 446.
[8] Richter, *op. cit.* v. 306.

On the other hand, Conradi, Bertele, and Horn,[1] consider it to be a *weakening agent* or *sedative*. Hence those who adopt this hypothesis must assume that the diseases in which mercury is beneficial are of a phlogistic or hypersthenic character; and that syphilis, therefore, is of this kind,—an explanation not at all satisfactory, nor consistent with facts. Of late years the sedative operation of some of the mercurial preparations (calomel and mercurial ointment) has been assumed (particularly by our countrymen practising in the East), from the circumstance that these agents allay vomiting and diarrhœa in yellow fever, cholera, and other dangerous diseases. But even admitting that mercurials do produce these effects, this is hardly a sufficient ground for denominating them sedatives.

Some think that mercurials in *small* or moderate doses are *stimulants*, but in *excessive* doses *sedatives;* and that this sedative operation is common to all substances when employed in large quantities. This is the opinion of Dr. Wilson Philip.[2]

Dr. Murray[3] calls mercury a tonic; Vogt[4] terms it an alterative resolvent; Sundelin[5] places it among the resolvent alteratives under the designation of liquefacient (*verflüssigende*). Mr. Hunter[6] accounts for its beneficial effects in syphilis, by saying it produces an irritation of a different kind to that caused by the venereal disease, and that it counteracts the latter by destroying the diseased action of the living parts.

In my opinion mercury is an alterative, and a liquefacient spanæmic (see *ante*, p. 175).

USES. 1. **Of Metallic Mercury.**—Liquid mercury has been used as a *chemical* agent to dissolve silver coins which may have been swallowed; and as a *mechanical* agent to remove obstructions of the bowels: for example, intus-susception, or intestinal invagination. But neither theory nor experience seem favourable to its use in the latter case; for in the greater number of cases the intus-susception is progressive—that is, the superior portion of the gut is insinuated into the lower portion, and therefore the pressure of the metal on the sides of the intestine cannot give relief; and even in cases of retrograde intus-susception—that is, where the lower portion of the bowels passes into the upper, mercury, instead of pressing the intus-suscepted portion back, might push it farther on, by getting into the angle of reflection between the containing and inverted gut.[7] *Lastly*, water, which had been boiled with mercury (*aqua mercurialis cocta*), was at one time used as an anthelmintic; but if the metal be pure, the water takes up no appreciable quantity of it. Moreover, it would appear that mercury has no particular anthelmintic powers: for persons who were salivated have not been freed from their worms, and Scopoli very frequently found ascarides in the workers of the quicksilver mines of Idria.[8]

ADMINISTRATION.—When taken internally, it has been administered in various doses, from an ounce to a pound or more.

2. **Of the Preparations of Mercury.**—As *errhines* or *emetics*, mercurials are never resorted to now, though formerly the *subsulphate* was used for these purposes.

As *alteratives*, they are given in small doses in various chronic diseases; such, for example, as dyspepsia, gout, chronic skin diseases, scrofula, &c. Calomel is said to be less beneficial as an alterative than blue pill, on account of its more irritating action on the bowels. The *hydrargyrum cum cretâ* is an excellent alterative, especially for children.

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[1] Quoted by Richter, *op. cit.* v. 307.

[2] *Op. cit.*

[3] *Syst. of Mat. Med.*

[4] *Pharmakodynamik.*

[5] *Heilmittellehre.*

[6] *Treatise on the Venereal Disease.*

[7] Hunter, *Transactions of a Society for the Improvement of Medical and Chirurgical Knowledge*, i. 103.

[8] Bremser, *Sur les Vers. Intest.* 428.

Certain preparations of mercury (as blue pill, calomel, and the *hydrargyrum cum cretâ*) are employed as *purgatives*. They promote secretion from the mucous follicles of the intestines, from the liver, and the pancreas. They are rarely, however, used alone; being, in general, either combined with, or followed by, other cathartics (as jalap, senna, colocynth, or the saline purgatives). Thus it is a common practice to exhibit a blue pill or calomel at night, and an aperient draught the following morning: the object being to allow the pill to remain as long as possible in the bowels, in order that it may the more effectually act on the liver. Mercurial purgatives are administered for various purposes; sometimes as anthelmintics, sometimes to assist in evacuating the contents of the alimentary canal, but more commonly with the view of promoting the secretions, particularly of the liver, or of producing counter-irritation, and thereby of relieving affections of other organs, as the skin or head.

The great value of mercurials is experienced when they are given as *sialogogues*. Formerly it was supposed that the beneficial effects of mercury were proportionate to the degree of ptyalism, and thus to eradicate particular affections it was thought necessary to cause the evacuation of a given quantity of saliva. "I have heard," says Dr. Wilson Philip,[1] "the late Dr. Monro, of Edinburgh, state the quantity of saliva which must be discharged daily to eradicate particular affections." Modern experience has proved the incorrectness of this notion; and we now rarely find it necessary to excite a high degree of salivation; indeed, frequently it would be prejudicial, but we sometimes find it requisite to keep up this effect for several weeks, particularly in diseases of a chronic character.

a. Production of sore mouth and salivation.—One of the most efficacious methods of putting the system under the influence of mercury is *friction* with the *unguentum hydrargyri*; but the troublesome and unpleasant nature of the process is a strong objection to it in practice, more especially in venereal diseases, in which patients usually desire secrecy. Full directions for its employment will be given hereafter (vide *Ung. Hydrargyri*). In the year 1779, Mr. Clare[2] proposed a new method of causing salivation by friction, and which consists in rubbing two or three grains of calomel, or of the suboxide of mercury, on the inner surface of the cheeks and gums. It is said that the metal quickly becomes absorbed, and causes salivation, and if care be taken not to swallow the saliva, diarrhœa does not occur. Notwithstanding that Hunter, Cruikshank, and others, have tried this plan, and reported favourably of it, and that it is free from the objections made to the use of mercurial ointment, it has never been a popular remedy. *Fumigation*, as a means of affecting the general system, is an old method of treating venereal diseases. Turner[3] employed for this purpose cinnabar; Lalouette[4] calomel; and the late Mr. Abernethy[5] the suboxide. Mr. Colles[6] has frequently seen fumigation fail in exciting salivation. He says, an easy mode of fumigating any part is by using *mercurial candles* (composed of cinnabar or oxide of mercury mixed with melted wax, with a wick, and burnt under a curved glass funnel.) Baumé used *mercurial pediluvia* to excite salivation, composed of half a grain of corrosive sublimate dissolved in a pint of distilled water, and in a solution of this strength the patient immersed his feet for the space of two hours; several objections, however, exist to the practice, which has been rarely followed. Upon the whole, the most convenient method of producing salivation is by the *internal use of mercurials*, particularly of those preparations which are mild in their local action, as blue pill, calomel, and the *hydrargyrum cum cretâ*.

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[1] *Op. cit.* p. 19.

[2] *Essay on the Cure of Abscesses by Caustic; also, a New Method of Introducing Mercury into the Circulation*, 1799.

[3] *On the Venereal Disease.*

[4] *Nouvelle Méthode de traiter les Malad. V*[illegible]

[5] *Surgical and Physiological Essays.*

[6] *Op. cit.* p. 58.

β. *Treatment before and during salivation.*—Formerly the use of mercurials was preceded by antiphlogistic measures, such as blood-letting, purging, warm bathing, and low diet, but they are now rarely resorted to, though useful by facilitating absorption. Mr. Colles[1] thinks that these preparatory measures have been improperly omitted, and that the want of them has, of late years, contributed to bring this valuable remedy into much disrepute—in which opinion I am disposed to join him. Occasionally great difficulty is experienced in affecting the mouth, a circumstance which may arise from the irritable condition of the bowels: and when this is the case, inunction should be resorted to, or opium or vegetable astringents conjoined. Sometimes, however, the system appears insusceptible to the influence of mercury, and this may arise from idiosyncrasy, or from the presence of some disease, particularly fever. Emetics and blood-letting are useful in these cases, as they promote absorption; and as the influence of the former depends on the state of nausea produced, tartar emetic will be the best vomit, since it is the most powerful nauseant. Varying the mode of administering the mercury will also sometimes facilitate its operation upon the system: thus, if it have been employed internally, inunction should be tried, and *vice versâ*.

During the time that the patient's mouth is sore, he should, if possible, confine himself to the house, use warm clothing, avoid exposure to cold, take light but nourishing food, and regulate the state of his stomach and bowels. Mr. Hunter thought that during a mercurial course the manner of living need not be altered, but Mr. Colles[2] has properly, I think, objected to this. If the discharge become excessive, or ulceration of the gums take place, the further use of mercury is of course to be stopped; and in order to moderate the effect already produced, the patient should be freely exposed to a cold but dry air, use purgatives and opium, and wash his mouth with some astringent and stimulating liquid. I have generally employed, as a gargle, a solution of the chloride of soda or of lime; but in the absence of these, a solution of alum, or of sulphate of copper, may be used. Dr. Watson[3] observes that "when the flow of saliva, and the soreness of the gums, form the chief part of the grievance, I have found nothing so generally useful as a gargle made of brandy and water; in the proportion of one part of brandy to four or five of water." With regard to internal remedies I have no confidence in any as having a specific power of stopping salivation, though iodine, sulphur, nitre, and other substances, have been strongly recommended. Sometimes sulphate of quina is administered with advantage.

γ. *Accidents during salivation.*—Occasionally, during salivation, certain effects result from mercury, which are in no way necessary or useful in a therapeutical point of view: on the contrary, some of them are highly prejudicial. Thus, sometimes, *excessive salivation, with ulceration of the gums*, takes place, as already noticed; not unfrequently *gastro-intestinal irritation* (or actual inflammation) comes on, and which may require the suspension of the use of mercury, or its employment by way of inunction, or its combination with opium or vegetable astringents. I have already noticed *fever, eczema mercuriale, mercurial erethysm* of Pearson, &c., as other occasional effects. In feeble and irritable habits, mercury sometimes disposes sores to *slough*. Occasionally a kind of *metastasis* of the mercurial irritation is observed: thus, swallowing a large quantity of cold water, or exposing the body to cold and moisture, has caused a temporary cessation of salivation, attended with violent pains or convulsions, or great irritability of stomach.

δ. *Curative action of salivation.*—Though no surgeon ascribes the curative action of mercury to the salivation, yet, without this effect, the curative influence is not usually observed. Hence, though the one cannot be considered to stand to the other in the relation of cause and effect, yet the two are usually contemporaneous: so that when we fail to induce some affection of the mouth, we do not observe the beneficial effects of mercury.[4]

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[1] *Practical Observations on the Venereal Disease*, p. 28.

[2] *Op. cit.* p. 34.

[3] *Lond. Med. Gaz.* Dec. 25, 1840.

[4] On this subject consult Colles, *op. cit.* p. 31.

Having offered these general remarks on salivation as a remedial agent, I proceed to notice its use in particular diseases.[1]

a. Fever.—It has been said that salivation diminishes the susceptibility to the contagion of fever, whether common or specific; but that it is not an absolute preventive is shown by the fact, that patients under the full influence of mercury have caught fever and died of it, as will be found noticed by my friend Dr. Clutterbuck, in his *Inquiry into the Seat and Nature of Fever.* I have several times used mercurials as sialogogues in fever; I believe, for the most part, with advantage. I have only used them when there was some marked local determination or inflammatory condition. I have seen several fatal cases of fever in which mercurials were used profusely, without having any effect on the mouth; but in other instances, in which the mouth became affected, recovery took place. My experience, therefore, agrees with that of Dr. Copland,[2] namely, that death, after salivation has been established, is very rare. Whether the recovery was the consequence of the mercurial action, or the salivation the result of the mitigation of the disorder, as Dr. Bancroft[3] and Dr. Graves[4] assert, cannot be positively proved, though I think the first more probable. Dr. Graves[5] declares the use of mercury in fever to be both injudicious and unnecessary, unless inflammation of some organ be set up. Dr. Macartney,[6] on the other hand, says, in no single instance have I known it [mercury] fail in arresting the progress of the disease, provided the fever be not combined with visceral affections, or characterized from the beginning with unusual prostration of strength." The great indisposition of the system in fever to take on the mercurial action, is frequently a most annoying circumstance. It may sometimes be overcome by the employment of mercurials both internally and externally. Mr. Lempriere,[1] who practised in Jamaica, finding that calomel was often exhibited in immense quantities without exciting any apparent action, was induced to employ corrosive sublimate in doses of the eighth part of a grain, with the addition of ten drops of laudanum, and this quantity was repeated every hour until some affection of the mouth was observed, or until the more alarming symptoms had considerably abated.

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[1] The following are Dr. Farre's rules for the exhibition of mercury (Ferguson, *op. supra cit.* p. 220):—

"1. Never to give mercury when there is an idiosyncrasy against it." The following case is illustrative of the danger of neglecting this advice:—

"A patient of Mr. G.'s, of the Borough, desired him never to give her any mercury, as that drug was a poison to her whole family, to which he, without arguing the point, at once assented. In Mr. G.'s absence, the late Mr. C. was consulted as to some trifling disorder of the bowels, and, not knowing the peculiarity of his patient's constitution, prescribed two grains of calomel. The next morning the lady shewed the prescription to Mr. C., saying that she was sure she had taken mercury, as she felt it in her mouth. In a few hours ptyalism ensued; in consequence of which she lost her teeth, her jaw exfoliated, and she ultimately, after a succession of ailments, died, in about two years."

"2. Mercury should be used in all active congestions—pyrexia, phlogosis, phlegmon, ophthalmia, strabismus, cynanche laryngea, cynanche trachealis, pneumonia, and in all inflammatory diseases. In the adhesive stages of dysentery, in the phlegmasiæ, where there is inflammation with power, in tetanus, hemiplegia, paraplegia, neuralgia, in their states of active congestion.

"3. Mercury is hurtful, or doubtful—in the malignant or asthenic forms of pyrexia, where there is low delirium; but in phrenitis, and in that peculiar form of it, the *coup de soleil,* it is most effectual. It is hurtful in tetanus from punctured wound, and in all cases of irritable disease.

"In idiopathic iritis, it is as effectual as bark in ague; but in the traumatic it is injurious, as it interferes with the closing of the vessels by adhesive inflammation: hence, in all hæmorrhage, where the orifices of vessels require to be closed, it is hurtful.

"In the hemiplegia of lesion, in asthenic paraplegia, in the neuralgia of irritation, it is bad. Poor Pemberton was three times salivated for tic douloureux, and three times the worse for it.

"It is hurtful in the inveterate forms of scrofulous ophthalmia, though useful in the early stage. It is bad in the amaurosis of depletion.

"It is useful in puerperal peritonitis, and hurtful in the typhoid form of it; as also in the ulcerative stage of dysentery.

"In general, it is doubtful in the suppurative stages of inflammation, and in all erysipelatous and erythematous inflammations, or those tending to gangrene. It is hurtful in all cases of pure asthenia from deficiency of red blood."

[2] *Dict. of Pract. Med.* i. 929.

[3] *On Yellow Fever.*

[4] *Lond. Med. Gaz.* xx. 147.

[5] *Op. cit.*

[6] *Treatise on Inflammation,* p. 162.

The beneficial influence of mercurials has been more particularly expeperienced in the fevers of warm climates, especially those of the East Indies.[2] It has been said by several writers,[3] that in the yellow fever of the West Indies its beneficial effects are not equally evident.

β. *Inflammation.*—Of late years various forms of inflammation have been most successfully combated by the use of mercury. Hence this mineral is termed an *antiphlogistic* We are principally indebted to Dr. Hamilton,[4] Dr. Yeats,[5] Dr. Wright,[6] and Rambach,[7] for its introduction into use in this form of disease. It is principally valuable in adhesive inflammation, to stop, control, or prevent the effusion of coagulable lymph. On the other hand, it may prove injurious in erythematous, scrofulous, malignant, and gangrenous inflammation, as well as in inflammation accompanied with debility or great irritability of the nervous system. Its curative power is not satisfactorily accounted for by the equalization of the circulation, the augmentation of the secretions, or the increased activity of the absorbents caused by mercury (see p. 176).

Mercury is not equally serviceable in all inflammations. The *nature of the tissue*, the *structure of the organ affected*, and the *quality* or *kind* of inflammation, are points of considerable importance as affecting its use.

Thus it appears that inflammations of *membranous tissues* are those principally benefited by a mercurial plan of treatment; and more especially those in which there is a tendency to the exudation of coagulable lymph or of serous fluid,—as meningitis, pleuritis, pericarditis, and peritonitis (particularly of puerperal women). In inflammation of the lining membrane of the air-tube, but more especially in croup, or, as it is sometimes termed, plastic inflammation of the larynx, mercury is one of our most valuable remedies; and as this disease is one which terminates rapidly, no time should be lost in getting a sufficient quantity of mercury into the system. Calomel is usually employed; but when the bowels are very irritable, the *hydrargyrum cum cretâ*, or even mercurial inunction, may be resorted to. In inflammation of the tunics of the eye, particularly iritis, mercury (next to bloodletting) is the only remedy on which much confidence can be placed; and we use it not merely with a view of putting a stop to the inflammatory action, but also in order to cause the absorption of the effused lymph.[1] In inflammation of the synovial membranes, mercury has been employed, and in some cases with manifest advantage. In dysentery, mercury has been extensively used, especially in warm climates. By some, calomel has been employed merely as a purgative (Jackson, Ballingall, Bampfield, and Annesley); by others, to produce its sialogogue effects (Johnson and Cunningham).

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[1] *Pract. Observ. on Diseases of the Army of Jamaica.*

[2] Johnson, *On Diseases of Tropical Climates*, pp. 32, 96, 97, 122, &c. &c. 3d edit.; Annesley, *On the Diseases of India*, p. 391, 2d edit.

[3] Johnson, *op cit.* p. 37; Bancroft, *On Yellow Fever;* Musgrave, *Edinb. Med. and Surg. Journ.* xxviii. 40.

[4] Duncan's *Med. Comm.* vol. ix.

[5] Duncan's *Ann. of Med.* vol. vii.

[6] *Med. Facts and Observ.* vol. vii.

[7] *Dissert. Usus Mercurii in Morb. Inflam.* 1794.

The *structure of the organ* influences the effect of mercury: at least it is well known that this mineral is more beneficial in inflammation of certain organs (especially those of a glandular structure, as the liver) than of others; and we refer it to some peculiarity in the structure of the part affected. In hepatitis of either temperate or tropical climates (particularly of the latter), mercury is advantageously employed.[2] Blood-letting, however, should be premised, particularly in the disease as usually met with in this country. In peripneumonia, more especially when hepatization has taken place, the best effects have sometimes resulted from its use: of course after the employment of blood-letting. When hepatization has taken place, Dr. Davies[3] recommends the use of blue pill and opium. In acute cases I prefer calomel and opium. In inflammation of the substance of the brain, also, mercury may be advantageously resorted to after the usual depletives.

The *nature* or *quality of the inflammation* also influences the effects, and thereby the uses, of mercury. Thus, in syphilitic inflammation, mercurials are of the greatest utility; less so in rheumatic inflammation; still less in scrofulous; and most decidedly objectionable in cancerous or scorbutic diseases. The treatment of rheumatism by calomel and opium was proposed by Dr. Hamilton,[4] and has found many supporters;[5] and, undoubtedly, when the febrile action does not run too high, or when the pericardium becomes affected, calomel and opium, preceded by bloodletting, will be found serviceable. It appears to be best adapted to the fibrous or diffuse form of the disease, and to fail in the synovial.[6] The scrofulous habit is, for the most part, unfavourable to the use of mercury given as a sialogogue, but there are cases in which it is not only admissible but serviceable,—as scrofulous ophthalmia, when of an acute kind. In all maladies of a malignant character (as cancers, fungoid diseases, &c.) mercurials are highly objectionable.

γ. *Venereal diseases.*—It was formerly the opinion of surgeons that the symptoms of the venereal disease were progressive, and never disappeared until mercury was administered; but it has, of late years, been clearly proved that this notion is erroneous: and we are indebted to some of our army surgeons,—namely, to Messrs. Ferguson, Rose, Guthrie,[7] Hennen,[8] and Bacot,[9] and to Dr. Thomson[1]—for showing that the venereal disease, in all its forms, *may* be cured without an atom of mercury. Moreover, it is fully established by the experience of almost every surgeon, that, while in some instances mercury exercises a beneficial influence hardly to be observed with respect to any other disease or any other remedy, yet that in some cases it acts most injuriously; and it is generally supposed that many of the bad venereal cases formerly met with arose, in great part, from the improper use of mercury. It is a point, therefore, of considerable importance, to determine what cases are best adapted for a mercurial, and what for a non-mercurial, method of treatment; for, in admitting the *possibility* of a cure without this agent, it is not to be inferred that the method is either *eligible* or *expedient*; nay, the very persons who have proved the possibility, admit that in some cases this mineral, given so as to excite moderate salivation, is advisable. One fact is, I think, tolerably well established, namely, that the cure of venereal diseases, without the aid of mercury, is much slower and less secure against relapses than by a mercurial treatment.[2] It is not easy to lay down rules to guide us in the selection of the one or the other of these methods of treatment. Mr. Carmichael[3] relies principally on the eruption, and, next to this, on the appearance of the primary ulcer; and of the four forms of the venereal disease which he has described, namely, the *papular*, the *pustular*, the *phagedenic*, and the *scaly*, full courses of mercury are required, he says, in one only, namely, the scaly; in which the primary sore is the Hunterian chancre or callous ulcer, and the eruption partakes of the characters of lepra or psoriasis. But it has been satisfactorily proved by experiments made in the military hospitals, that even this scaly form of the disease may get well without mercury; and, on the other hand, in the pustular and papular forms, mercury is often a most valuable agent. Hennen, Rose, Guthrie, and Thomson, advise the employment of moderate quantities of mercury whenever the disease does not readily subside under the use of ordinary methods of treatment. But unless some special circumstances contraindicate the use of mercury, it is, I think, advisable to affect the mouth slightly in most forms of the disease.

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[1] Lawrence, *Lectures on Diseases of the Eye*, in *Lancet*, vol. x. p. 198; Mackenzie, *On Diseases of the Eye*, 2d edit. pp. 389, 394, and 503.

[2] Sir James M'Grigor, *Medical Sketches*; Johnson, *On Tropical Climates*; Annesley, *On Diseases of India*.

[3] *Lectures on Diseases of the Lungs*, &c. p. 191.

[4] *Op. cit.*

[5] *Vide* Dr. Hope, *Lond. Med. Gaz.* xix. 815.

[6] Dr. Macleod, *Lond. Med. Gaz.* xxi. 361.

[7] *Med. Chirurg. Trans.* vols. iv. and viii.

[8] *Military Surgery.*

[9] *On Syphilis*, 1821.

The circumstances which deserve attention, as affecting the use of mercury, are numerous. The following are the principal:—

αα. Scrofula.—Some of the worst and most intractable forms of venereal disease occur in scrofulous subjects; and in such, mercury is in general prejudicial. I have seen numerous instances of its injurious effects. One case which fell under my notice was that of a medical student, who, after three years' suffering, died; having been made much worse on two occasions by what I conceived to be the improper use of mercury, once by his own act, and a second time by the advice of the surgeon of his family. Mr. Colles,[4] however, denies the baneful influence of mercury in scrofula, and advises its use for the cure of syphilis in scrofulous subjects; but he admits that the profession generally entertain a contrary opinion.

ββ. Condition of the primary ulcer.—Another point deserving attention in deciding on the use of mercury, is the condition of the primary sore; if it be much inflamed, or of an irritable nature—if it be of the kind called phagedenic, or at all disposed to slough—mercury must be most carefully avoided, as it increases the disposition to sloughing. In one case that fell under my notice, a gentleman lost his penis by the improper use of mercury, under the circumstances just mentioned.

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[1] *Ed. Med. and Surg. Journ.* xiv.

[2] *Vide* Colles, *Practical Observations on the Venereal Disease*, p. 318.

[3] *On Venereal Diseases*, 2d edit. 1825.

[4] *Op. cit.* p. 236.

γγ. *Extreme debility with hectic fever.*—This condition is usually believed to contraindicate the employment of mercury. But Mr. Colles[1] asserts, "that a patient affected with secondary symptoms, even though extremely attenuated, and, as it were, melting away under the effects of hectic, can with perfect safety and advantage at once commence a course of mercury; by which not only shall his venereal symptoms be removed, but at the same time his general health be re-established."

δ. *Cholera.*—Writers on the spasmodic cholera, both of this country and of India, speak for the most part favourably of the effects of mercury, especially in the form of calomel. I may refer to the works of Drs. Johnson, Venables, and Hamett, and of Messrs. Annesley, Orton, and Searle, in proof. I have met with no writers who attribute ill effects to it. Unfortunately those who advocate its use are not agreed as to the dose, or frequency of repetition: some advising it as a purgative; some as a sedative, in combination with opium; others, lastly, using it as a sialogogue. It is deserving of especial notice, that, when salivation takes place, the patient in general recovers. Dr. Griffin,[2] however, has shewn that this is not invariably the case. (For further information on the use of mercurials in cholera, see *Calomel.*)

ε. *Dropsy.*—In this disease, mercurials may do either good or harm. Thus, when the dropsical effusion depends on inflammation, they may be employed with the best effects, as when hydrocephalus arises from meningitis, or hydrothorax from pleuritis. When ascites is occasioned by an enlarged liver, which compresses the vena portæ, and thereby gives rise to effusion, mercurials are sometimes beneficial. On the contrary, when dropsy occurs in old subjects, and when it depends on, or is accompanied by, general debility, salivation is almost always hurtful. In granular degeneration of the kidney, characterised by an albuminous condition of the urine, its use is highly objectionable. It is of no service to the primary disorder, while its effect on the mouth is often very violent and uncontrollable. When the effusion arises from mechanical causes not removable by mercury, as obliteration of any of the venous trunks, or pressure of malignant tumors, salivation is injurious. Occasionally dropsical effusion takes place without any appreciable cause, and then, of course, if mercury be employed, it must be in part on speculation. In such cases, calomel is not unfrequently employed in combination with squills or foxglove.

ζ. *In chronic diseases of the viscera,* especially those arising from or connected with inflammation, mercury is frequently serviceable. Thus, in enlargement or induration of the liver, in hepatization of the lungs, &c. In those diseases commonly termed malignant, as cancer and fungus hæmatodes, and also in diseases of a non-malignant character, but occurring in debilitated subjects, mercurials, given so as to excite salivation, are objectionable. In diseased spleen they are usually injurious (see *ante,* p. 233).

η. *In chronic diseases of the nervous system.*—Mercury has been recommended in paralysis, and on some occasions has proved exceedingly efficacious. I have repeatedly seen hemiplegia, with impaired vision and hearing, headache, and cramps of the extremities, recover under the use of mercury, after blood-letting, purgatives, &c. had failed. In one case the patient (a young man) was kept under the influence of the medicine for two months. Mr. Colles[1] has likewise found it most efficacious in paralysis. In tetanus, mania, epilepsy, hysteria, tic douloureux, and other affections of the nervous system, mercury has been used with occasional benefit.

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[1] *Op. cit.* p. 206.

[2] *Lond. Med. Gaz.* xxi. p. 882.

The foregoing are some of the most important diseases against which mercurials have been successfully administered as sialogogues.

HYDRARGYRUM PURIFICATUM, D.; *Purified Mercury.* (Take of Mercury, *six parts.* Let four parts slowly distil.)—The characters of pure mercury have been already stated. As found in commerce, mercury is usually very pure, and therefore the process of purification directed by the Dublin College is unnecessary. By means of a common fire, mercury may be readily distilled in an earthen retort, to which a curved earthen tube, dipping into water, is adapted. A wash-hand basin, containing water, answers as a receiver. The whole of the mercury may be drawn over. The object of the process is to separate this metal from lead, tin, zinc, and other metals with which it may be contaminated.

158. HYDRARGYRUM CUM CRETA.—MERCURY WITH CHALK.

HISTORY.—This compound (called, also, *mercurius alcalisatus,* or *æthiops absorbens*) is first mentioned, I believe, by Burton, in 1738.

PREPARATION.—All the British Colleges give directions for its preparation.

The *London College* directs us to take of Mercury, ℥iij.; Prepared Chalk, ℥v. Rub them together until globules are no longer visible. The directions of the *Edinburgh College* are similar.

The *Dublin College* orders it to be prepared like *Hydrargyrum cum Magnesiâ,* except that precipitated carbonate of lime is to be employed in the place of carbonate of magnesia.

If this powder be digested in acetic acid, the lime of the chalk is dissolved, and the carbonic acid escapes; but the greater part, if not the whole, of the mercury is insoluble in the acid, and hence it is not in the state of suboxide. If examined by a lens, the residuum is found to consist of minute separate globules, which readily whiten silver and gold, showing they are in the metallic state. Hence it is probable that the quicksilver is mechanically divided only.

PROPERTIES AND CHARACTERISTICS.—It is a greyish powder, which effervesces on the addition of acetic acid, yielding a solution of lime, which may be distinguished by the tests for the calcareous salts already mentioned. By digestion in nitric acid, we obtain a solution known to contain mercury by the characters already detailed for the mercurial preparations generally. By heat the mercury is volatilized, leaving the chalk.

Part is evaporated by heat; what remains is colourless, and totally soluble in acetic acid with effervescence: this solution is not coloured by hydrosulphuric acid. These substances can scarcely be so diligently triturated as that no globules shall be visible.—*Ph. Lond.*

COMPOSITION.—It is a mechanical mixture of three parts of finely divided *mercury* and five of *chalk*.

PHYSIOLOGICAL EFFECTS.—It is an exceedingly mild but valuable mercurial. In full doses it acts as a gentle laxative, promoting the secretion of bile and intestinal mucus, but sometimes creating a little sickness. The chalk renders it antacid. By repeated use it occasions the constitutional effects of mercury already described.

USES.—It is a valuable remedy in *syphilis infantum*. It is frequently employed to promote and improve the secretions of the liver, pancreas, and bowels, in various disordered conditions of the digestive organs, accompanied by clay-coloured stools or purging. In strumous affections of children (especially enlarged mesenteric glands) and other chronic maladies, it is administered with great advantage as an alterative.

ADMINISTRATION.—To adults it is given in doses of from five grains to a scruple or half a drachm. It should be given in the form of powder. Pills made of it, and allowed to become hard, present internally large globules of mercury. This arises from the contraction of the substance used to form the pill mass, by which the minute globules are squeezed out and coalesce. For children the dose is two or three grains. Rhubarb, carbonate of soda, or, in some cases, Dover's powder, may be conjoined with it.

159. HYDRARGYRUM CUM MAGNESIA.—MERCURY WITH MAGNESIA.

The Dublin Pharmacopœia gives the following directions for the preparation of this compound:—

> Take of purified Mercury; Manna, of each, *two parts*; Carbonate of Magnesia, *one part*. Rub the mercury with the manna in an earthenware mortar, adding a few drops of water, that the mixture may have the consistency of a syrup, and that the metallic globules, by continued trituration, may disappear; then add, still triturating, an eighth part of Carbonate of Magnesia. To the whole, thoroughly mixed, add of warm water sixteen parts, and let the mixture be stirred; then let it rest, and, as soon as the sediment has subsided, let the liquor be decanted; repeat the washing again, and a third time, that the manna may be completely washed off; then mix with the sediment, whilst moist, the remainder of the Carbonate of Magnesia. Lastly, let the powder be dried on bibulous paper.

The manna is employed to effect the minute division of the mercury. By the water subsequently employed the manna is got rid of. The effects, uses, and doses of this preparation, are similar to those of *hydrargyrum cum cretâ*.

160. PILULÆ HYDRARGYRI.—PILLS OF MERCURY.

HISTORY.—The oldest formula for mercurial pills is that of Barbarossa (at one time admiral of the Turkish fleet, and afterwards sultan of Algiers), and which was communicated by him to Francis the First, king of France, who made it public. The common name for this preparation is *blue pill*, or *pilula cærulea*.

PREPARATION.—The following are the directions of the British Colleges for the preparation of these pills:—

Take of Mercury, ʒij. [*two parts*, E.]; Confection of Red Roses, ʒiij. [*three parts*, E.]: Liquorice Root, powdered [Extract of Liquorice, reduced to fine powder, *D.*], ʒj. [*one part*, E.] Rub the mercury with the confection until globules can no longer be seen; then, the Liquorice being added, beat the whole together until incorporated. [Divide the mass into five-grain pills, *E.*].

The friction is usually effected by steam power. By trituration, the metal is reduced to a finely divided state, and becomes intimately mixed with the confection and liquorice powder.

PROPERTIES.—It is a soft mass, of a convenient consistence for making into pills, and has a dark blue colour. When rubbed on paper or glass, it ought to present no globules; but applied to gold it communicates a silvery stain.

COMPOSITION.—Three grains of this pill contain one grain of mercury.

IMPURITY.—If any sulphuric acid should have been added to the confection to brighten its colour, some subsulphate of mercury will be formed—a compound which possesses very energetic properties.

In a circular issued by the College of Pharmacy of New York,[1] it is stated that the following mixture was imported from a manufactory in a provincial town in England, and sold as blue pill:—*Mercury* 7·5, *earthy clay* 27·0, *Prussian blue*, used in colouring, 1·5, *sand*, in combination with the clay, 2·0, *soluble saccharine matters* 34·0, *insoluble organic matters* 12, and *water* 16·0=100·0.

PHYSIOLOGICAL EFFECTS.—In full doses (as from five to fifteen grains) it frequently acts as a purgative. In small doses it is alterative, and, by repetition, produces the before-mentioned constitutional effects of mercurials.

USES.—The practice of giving a blue pill at night, and a senna draught the following morning, has become somewhat popular, in consequence of its being recommended by the late Mr. Abernethy, in various disorders of the chylopoietic viscera. As an alterative, in doses of two or three grains, blue pill is frequently resorted to. Lastly, it is one of the best internal agents for exciting salivation in the various diseases for which mercury is adapted.

ADMINISTRATION.—The usual mode of exhibiting it is in the form of pill, in the doses already mentioned; but it may also be administered when suspended in a thick mucilaginous liquid. If the object be to excite salivation, we may give five grains in the morning, and from five to ten in the evening; and to prevent purging, opium may be conjoined.

161. UNGUENTUM HYDRARGYRI.—OINTMENT OF MERCURY.

HISTORY.—Mercurial ointment was known to, and employed by, the ancient Arabian physicians—for example, Abenguefit, Rhazes, and Avicenna; so that it has been in use certainly 1000 years. However, Gilbertus Anglicus, who lived about the commencement of the thirteenth century, was the first who gave a detailed account of the method of extinguishing mercury by fatty matters. Besides its more common appellation of *mercurial ointment,* it was formerly termed *blue* or *neapolitan ointment.*

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[1] *Pharmaceutical Journal*, vol. vii. p. 251, 1847.

PREPARATION.—The following are the directions for preparing the *unguentum hydrargyri,* E. D., or *unguentum hydrargyri fortius,* L.:—

Take of Mercury, ℔ij.; Lard, ℥xxiij.; Suet, ℥j. First rub the mercury with the Suet and a little of the Lard until globules can no longer be seen; then add that which is left of the Lard, and mix. *L. E.*—The *Dublin College* uses equal parts of Purified Mercury and prepared Hog's Lard.—The *Edinburgh College* observes, that "This ointment is not well prepared so long as metallic globules may be seen in it with a magnifier of four powers."

To promote the extinction of the mercury, the metal should be previously triturated with some old mercurial ointment. Rancid lard also assists the extinction of the globules.

The mercury is in a finely-divided metallic state. Guibourt[1] states that, by digesting ether on mercurial ointment, the fatty matter may be dissolved, and liquid mercury obtained in equal weight to that used in making the ointment. Mr. Donovan, however, thinks that part of the mercury attracts oxygen, and that the oxide thus formed unites with the fatty matter. I have seen no satisfactory explanation of the efficacy of old mercurial ointment in extinguishing the mercury: Guibourt offers the following:—By trituration, both lard and mercury assume oppositely electrical states, the lard becoming negative, the mercury positive: these states, he supposes, determine a more intimate mixture of the particles, and a greater division of the mercury. Now rancid lard and old mercurial ointment, having attracted oxygen from the air, more readily take on the negative condition, and hence their efficacy in promoting the extinction of the mercurial globules. Guibourt also asserts that mortars of marble or wood are better adapted for making this ointment than those of metal, on account of their power of conducting electricity being less.

PROPERTIES.—It is an unctuous fatty body of a bluish-grey colour, and if properly prepared, gives no traces of globules when rubbed on paper and examined by a magnifier of four powers; but when rubbed on gold, it quickens it. When examined by a powerful microscope, innumerable globules are observed. In well-made mercurial ointment these globules are not discernible by the naked eye, being from 1-500th to 1-1000th of a line in diameter.[2] I found the sp. gr. of a sample obtained from Apothecaries' Hall to be 1·7813 at 60° F. Two other samples, procured from two respectable houses, had respectively a sp. gr. of 1·6602 and 1·7603. Mercurial ointment should be kept in a moderately warm situation during the winter season, for when exposed to great cold the mercury separates in a liquid form, by the crystallization, I presume, of the fatty matter.

COMPOSITION.—This compound consists of equal weights of *fatty matter* and finely divided *mercury.*

STRENGTH AND PURITY.—Mercurial ointment is frequently prepared with a smaller proportion of mercury than that directed to be used in the Pharmacopœias; and in order to communicate to it the requisite shade of colour, tersulphuret of antimony, indigo, or Prussian blue, is sometimes intermixed.

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[1] *Pharm. Raisonnée,* ii. 140.

[2] Ehrenberg, in Poggendorff's *Annalen,* xxiv. 40.

In order to ascertain the strength and purity of a given sample, it is desirable to obtain a standard by way of comparison. I have always used for this purpose the ointment prepared at Apothecaries' Hall, London.

The qualities which should be attended to, in order to judge of a suspected sample, are its colour, and its appearance under a magnifier of four powers, as well as under a powerful microscope. By the latter we judge of the size of the globules, their number, and the presence of foreign particles. Its sp. gr. should then be observed. The fatty matter should afterwards be separated from the mercury, and the latter carefully weighed. This is to be effected by means of ether or turpentine. To separate completely the fatty matter, Mr. C. Watt[1] gives the following directions :—Having first melted the fatty matter with boiling water, and allowed it to stand till the greater part of it floated on the surface, pour off the fluid fat, and then boil this mercury in a dilute solution of soap [or caustic alkali] until the metal collects in one globule.

Physiological Effects.—Mercurial ointment possesses very little power of irritating the parts to which it is applied; but when either swallowed or rubbed into the integuments, it readily produces the constitutional effects of mercury. Thus Cullerier says, that three or four pills, containing each two grains of this ointment, and taken successively, have often sufficed to excite violent salivation. He also tells us, that if the object be to produce ptyalism in a very short space of time, we may effect it by giving half a drachm of the ointment in the space of twenty-four hours.

When rubbed on the skin it is capable of producing the before-mentioned constitutional effects of mercurials: and if the lard which it contains be not rancid, no obvious local effect is usually produced. Applied to ulcerated surfaces, mercurial ointment is a stimulant, and in syphilitic sores is oftentimes a very useful and beneficial application.

Uses.—It is rarely or never administered *internally* in this country, but has been much used on the continent, and with great success. Cullerier says, the difficulty with him has been rather to check than to excite salivation by it.

Applied *externally*, it is employed either as a local or constitutional remedy. Thus, as a *local* agent it is used as a dressing to syphilitic sores, and is rubbed into tumors of various kinds (not those of a malignant nature, as cancer and fungus hæmatodes), with the view of causing their resolution. Sometimes, also, it is employed to destroy parasitic animals on the skin. As a *means of affecting the constitution* we use mercurial inunctions in syphilis, in inflammatory diseases, and, in fact, in all the cases (already noticed) in which our object is to set up the mercurial action in the system, more especially when the irritable condition of the digestive organs offers an objection to the internal employment of mercurials. It may be laid down as a general rule, that mercury may be used with more safety by the skin than by the stomach; but reasons of convenience, which I have already alluded to, frequently lead us to prefer its internal use.

Administration.—*Internally*, it is given in doses of from two to five grains, made into pills, with either soap or some mild powder, as liquorice. *Externally*, when the object is to excite very speedy salivation, half a drachm may be rubbed into the skin every hour, washing the part each time, and varying the seat of application. If, however, it be not desirable or necessary to produce such a speedy effect, half a drachm, or a drachm, rubbed in night and morning, will be sufficient. During the whole course of innunction the patient should wear the same drawers night and day.

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[1] *The Chemist*, No. xiv. Feb. 1840.

When the friction is performed by a second person, the hand should be enveloped with soft oiled pig's bladder, turned inside out.[1] Mercurial frictions ought not to be violent, but long continued, and had better be carried on near a fire, in order to promote the liquefaction and absorption of the ointment. In syphilis, and other diseases in which our sole object is the constitutional affection, it matters little to what part of the body the ointment is applied, provided the cuticle be thin (for this layer offers an impediment to absorption in proportion to its thickness). The internal parts of the thighs are usually, therefore, selected. However, in liver complaints, the innunctions are made in the region of the organ affected. The occasional use of the warm bath promotes absorption when the ointment is applied to the skin.

1. **UNGUENTUM HYDRARGYRI MITIUS**, L. D.; *Milder Mercurial Ointment.* (Stronger Mercurial Ointment, lbj.; Lard, lbij. Mix. *L.*—The *Dublin College* orders it to be made with double the weight of lard.—The *Edinburgh College* merely observes, that "the mercurial ointment, with the proportions here directed (see p. 833), may be diluted at pleasure with twice or thrice its weight of axunge.")—This preparation is applied as a dressing to ulcers and cutaneous diseases.

2. **CERATUM HYDRARGYRI COMPOSITUM**, L.; *Compound Cerate of Mercury.* (Stronger ointment of Mercury; Soap Cerate, each ℥iv.; Camphor, ℥j. Rub them together until they are incorporated.)—Employed as a resolvent application to enlarged joints and indolent tumors. This preparation was introduced into the Pharmacopœia on the recommendation of the late Mr. Scott.[2]

3. **LINIMENTUM HYDRARGYRI COMPOSITUM**, L.; *Compound Liniment of Mercury.* (Stronger Ointment of Mercury; Lard, each ℥iv.; Camphor, ℥j.; Rectified Spirit, fʒj.; Solution of Ammonia, f℥iv. Rub the camphor first with the spirit, then with the lard and ointment of mercury; lastly, the solution of ammonia being gradually poured in, mix them all.)—It is used (by way of friction) in chronic tumors, chronic affections of the joints, &c., where the object is to excite absorption. It is said to cause salivation more readily than the common mercurial ointment, owing to the camphor and ammonia.

162. EMPLASTRUM HYDRARGYRI.—PLASTER OF MERCURY.

Both the London and Edinburgh Colleges give formulæ for the preparation of this plaster,

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[1] Colles, *op. cit.* p. 42[illegible]

[2] *Surgical Observations on the Treatment of Chronic Inflammation in various Structures, particularly as exemplified in Diseases of the Joints*, Lond. 1828.

The *London College* orders of Mercury, ℥iij.; Plaster of Lead, lbj.; Olive Oil, fʒj.; Sulphur, grs. viij. To the heated Oil add the Sulphur gradually, stirring constantly with a spatula until they incorporate; afterwards rub the Mercury with them until globules are no longer visible; then gradually add the Plaster of Lead, melted with a slow fire, and mix them all.

In this process the sulphur of the sulphurated oil (see p. 346) unites with part of the mercury. The remainder of the metal becomes mechanically divided.

The *Edinburgh College* orders of Mercury, ℥iij.; Olive Oil, fʒix.; Resin, ʒj.; Litharge Plaster, ℥vj. Liquefy together the oil and resin, let them cool, add the mercury, and triturate till its globules disappear; then add to the mixture the plaster previously liquefied; and mix the whole thoroughly.

It is supposed to stimulate the lymphatic vessels of the parts to which it is applied, and is used as a discutient in glandular enlargements and other swellings, whether venereal or otherwise, and also to the region of the liver in hepatic complaints. Dr. Wilson Philip[1] has seen it induce salivation.

EMPLASTRUM AMMONIACI CUM HYDRARGYRO, L. D.; *Emplastrum Ammoniaci et Hydrargyri*, E.; *Plaster of Ammoniacum with Mercury.* (Ammoniacum, lbj.; Mercury, ℥iij.; Olive Oil, fʒj.; Sulphur, grs. viij. To the heated Oil gradually add the Sulphur, stirring constantly with a spatula until they incorporate; then rub the Mercury with them until globules are no longer visible; lastly, gradually add the Ammoniacum, melted, and mix them all. *L. E.*—The *Dublin College* orders purified mercury; and, instead of the olive oil and sulphur, directs two drachms of Common Turpentine to be used.)—It is a more powerful compound than the preceding, and is employed in the same cases, especially to disperse venereal buboes. It frequently excites an eczematous eruption.

163. HYDRARGYRI SUBOXYDUM.—SUBOXIDE OF MERCURY.

Formula Hg^2O. *Equivalent Weight* 208.

HISTORY.—The mode of preparing this compound was taught by Moscati, in 1797. This oxide is sometimes termed the *protoxide*, *oxide*, *dioxide*, *ash*, *grey*, or *black oxide*, (*hydrargyri oxydum*, vel *hydrargyri oxydum cinereum*, seu *hydrargyri oxidum nigrum*).

PREPARATION.—The following are the directions of the London and Dublin Colleges for its preparation:—

The *London College* orders of Chloride of Mercury, ʒj.; Lime Water, *Cong.* j. Mix and frequently shake them. Set by, and when the oxide has subsided, pour off the liquor. Lastly, wash it in distilled Water until nothing alkaline can be perceived, and dry it, wrapped in bibulous paper, in the air.

In this process double decomposition takes place: chloride of calcium is formed in solution, while suboxide of mercury precipitates. $Hg^2Cl + CaO = Hg^2O + CaCl$.

The following is the process of the *Dublin College*:—

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[1] *Op. cit.*

Take of Sublimed Calomel, one part; Water of Caustic Potash, made warm, four parts. Let them be triturated together until an oxide of a black colour is obtained, and let this be frequently washed with water: lastly, let the oxide be dried with a *medium* heat on bibulous paper.

In this process the reactions are similar to those of the preceding one; but as potash is used instead of lime, the products are chloride of potassium in solution, and suboxide of mercury precipitated. $Hg^2Cl + KO = Hg^2O,KCl$.

PROPERTIES.—Pure suboxide of mercury is black, or nearly so. The present preparation, however, is frequently greyish, owing to the presence of some undecomposed calomel. It is readily decomposed by light (especially by the solar rays), becomes olive-coloured, and is resolved into metallic mercury and the red oxide. It is odourless, tasteless, insoluble in water and alkalies, but is soluble in nitric and acetic acids. By the action of hydrochloric acid it forms water and calomel. When heated it is first decomposed, and then completely dissipated.

Characteristics.—Heated in a glass tube it evolves oxygen, while metallic globules are sublimed. Dissolved in diluted nitric acid it forms a protomercurial salt, known by the before-mentioned characters for these substances.

COMPOSITION.—The composition of this oxide is as follows :—

	Atoms.	*Eq. Wt.*	*Per Cent.*	*Sefström.*	*Thénard.*
Mercury	2	200	96·15	96·2	96·16
Oxygen	1	8	3·85	3·8	3·84
Suboxide of Mercury	1	208	100·00	100·0	100·00

PURITY.—Digested, for a short time, in dilute hydrochloric acid, the solution, when filtered, should form no precipitate with either potash or oxalate of ammonia. If any red oxide had been dissolved, the potash would throw it down as a reddish or yellowish hydrate. If any carbonate of lime had been present, the oxalate would recognise the presence of calcium in the solution.

Digested for a short time with diluted hydrochloric acid and strained, neither solution of potash nor oxalate of ammonia throws down any thing. It is totally soluble in acetic acid. By heat it is entirely dissipated.—*Ph. Lond.*

PHYSIOLOGICAL EFFECTS.—Pure suboxide of mercury is one of the least irritating of the mercurial preparations, and, therefore, when swallowed does not produce much disorder of the alimentary canal. In small doses it acts as an alterative and purgative. When taken in repeated doses, its constitutional effects are similar to those of other mercurials.

USES.—Mr. Abernethy employed it as a fumigating agent. The following are his directions for using it :—Place the patient in a vapour bath, in a complete suit of under garments, with a cloth around his chin. Two drachms of the oxide are then to be put on a heated iron within the machine in which the patient is sitting. After continuing in the bath for about fifteen or twenty minutes, the body is found to be covered with a whitish powder. The patient should be placed in bed, and lie in the same clothes till morning, and then go into a tepid bath. By this mode of proceeding Mr. Abernethy says he has known salivation induced in forty-eight hours.

Suboxide of mercury is rarely employed as an internal remedy; indeed, its varying composition is a strong objection to its use. As an external application it has been used in the form of *ointment* (composed of one part of oxide and three parts of lard), and also suspended in a weak solution of chloride of calcium, under the name of *black wash.*

ADMINISTRATION.—For internal use the dose is from half a grain to two or three grains.

LOTIO NIGRA; *Black Wash; Aqua Mercurialis nigra; Aqua Phagedænica mitis.*—This is prepared by adding calomel to lime-water. The proportions of the ingredients may be varied, but in general one drachm of calomel is used to a pint of lime-water. Suboxide of mercury precipitates, and chloride of calcium remains in solution. As the efficacy of the wash depends on the suboxide, the bottle must be well shaken every time of using it. This compound is a favourite application to venereal sores of almost all kinds,—in most being serviceable, in few or none being hurtful.

164. HYDRARGYRI OXYDUM RUBRUM.—RED OXIDE OF MERCURY.

Formula HgO. *Equivalent Weight* 108.

HISTORY.—This is the *peroxide* or *binoxide of mercury* of some writers. Geber[1] describes the method of making that variety of it which is prepared by calcination, and which was formerly called *red precipitate per se* (*mercurius præcipitatus ruber per se*), or *calcined mercury* (*hydrargyrum calcinatum*). He calls it *coagulated mercury.*

PREPARATION.—This compound may be prepared either by precipitation or by calcination.

The *London College* directs it to be prepared by precipitation; and orders of Bichloride of Mercury, ℥iv.; Solution of Potash, f℥xxviij.; Distilled Water, Oij. Dissolve the Bichloride of Mercury in the Water; strain, and add the Solution of Potash. The liquor being poured off, wash in distilled water the powder thrown down, until nothing alkaline can be perceived, and dry it with a gentle heat.

In this process one equivalent of corrosive sublimate is decomposed by an equivalent of potash, and yields one equivalent of red oxide of mercury, and an equivalent of chloride of potassium. $HgCl + KO = HgO + KCl$.

The *Dublin College* orders it to be prepared by calcination as follows: Take of purified mercury any required quantity, passed into a glass vessel with a narrow mouth and broad bottom; let it be exposed to a heat of about 600° F. until it is converted into red scales.

The heat vapourizes the mercury, which in this state attracts oxygen from the air, and forms this red or peroxide. The long neck of the vessel prevents the escape of the vapours of the newly-formed oxide.

The process is a very tedious one, occupying several weeks: so that Geber's remark was correct that "it is a most difficult and laborious work, even with the profoundness of clear-sighted industry." The apparatus which Mr. Boyle contrived for the manufacture of it, was long termed "*Boyle's Hell,*" from a notion that the mercury was tortured in it.

PROPERTIES.—When prepared by precipitation it is in the form of an orange-red powder: but when made by calcination, it occurs in small brilliant scales of a ruby red colour. Both varieties agree in the following properties: they are odourless, have an acrid metallic taste, are very slightly soluble in water,[1] but readily soluble in both nitric and hydrochloric acids. They are decomposed and reduced by heat and solar light; the precipitated variety is more readily acted upon by solar light than the variety made by calcination.

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[1] *Sum of Perfection*, book i. part iv. ch. 16.

Characteristics.—When heated in a glass tube by a spirit lamp, it is decomposed into oxygen and mercury: the first may be recognised by a glowing match, the second condenses in small globules. It dissolves completely in hydrochloric acid; the solution contains corrosive sublimate, which may be known by the tests hereafter to be mentioned for this substance.

COMPOSITION.—The composition of this substance is as follows:—

	Atoms.	*Eq. Wt.*	*Per Cent.*	*Sefström.*	*Donovan.*
Mercury	1	100	92·59	92·68	92·75
Oxygen	1	8	7·41	7·32	7·25
Red Oxide of Mercury	1	108	100·00	100·00	100·00

Red oxide of mercury prepared by precipitation usually contains some water.

PURITY.—Red oxide of mercury should be completely dissipated by heat, and be insoluble in water. Its solution in nitric acid should be unaffected by nitrate of silver, by which the absence of any chloride is shown. If an insufficient quantity of potash be employed in the preparation of the precipated variety, the product is brownish or brick-dust coloured, and contains oxichloride of mercury (composed, according to Souberain,[2] of HgCl,3HgO).

On the application of heat it yields oxygen, and the mercury either runs into globules or is totally dissipated. It is entirely soluble in hydrochloric acid.—*Ph. Lond.*

PHYSIOLOGICAL EFFECTS.—Red oxide of mercury is a powerful irritant, and when taken internally, even in small doses, readily excites vomiting and purging: large doses excite gastro-enteritis. Orfila[3] found that the red oxide, obtained by precipitation from four grains of corrosive sublimate, killed a dog in eighteen minutes. The constitutional effects of this preparation are the same as those of mercurials generally.

USES.—Red oxide of mercury is rarely employed as a medicine. It has been applied as an escharotic, either in the form of powder or ointment. Internally it was formerly exhibited to excite salivation in venereal diseases, but is objectionable, especially where the bowels are morbidly irritable. It is rarely or never used now.

In pharmacy it is employed in the preparation of cyanide of mercury.

ADMINISTRATION.—The dose of it is from a quarter of a grain to one grain, given in the form of a pill, in combination with opium.

LOTIO FLAVA; *Lotio* (seu *Aqua*) *Phagedænica; Yellow* or *Phagedenic Wash.*—This compound, which was formerly in frequent use, is prepared by adding corrosive sublimate to lime-water. The proportions vary in different formulæ. The quantity of sublimate should not, I think, exceed two grains to an ounce of lime-water: the usual proportions are thirty grains to sixteen ounces of lime-water. The preparation, then, consists of the hydrated red-oxide of mercury (which precipitates), chloride of calcium, and caustic lime; the two latter being in solution. But if the quantity of corrosive sublimate exceed $3\frac{7}{10}$ grains to an ounce of lime-water, the precipitate is brown or brickdust coloured, and contains oxichloride of mercury, while the clear liquor holds in solution some hydrargyro-chloride of calcium; that is, a saline combination in which chloride of calcium is the base, and corrosive sublimate the acid.[1] Yellow or phagedenic wash is applied, by means of lint, to venereal and scrofulous ulcers. Dr. Hintze[2] used it with advantage in chronic ulcers which succeed to burns. It should be well shaken, and used in the turbid state.

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[1] *Journ. de Pharm*, t. xxiv. p. 252.

[2] Dumas, *Traité de Chimie*, iii. 615.

[3] *Toxicol. Gén.*

165. HYDRARGYRI NITRICO-OXYDUM.—NITRIC OXIDE OF MERCURY.

HISTORY.—This preparation was known to Raymond Lully in the latter part of the thirteenth century. It is commonly termed *red precipitated mercury* (*mercurius precipitatus ruber*), or, for brevity, *red precipitate*.

PREPARATION.—All the British Colleges give directions for the preparation of it.

The *London College* orders of Mercury, lbiij.; Nitric Acid, lbiss.; Distilled Water, Oij. Mix them in a proper vessel, and apply a gentle heat until the mercury is dissolved. Boil down the liquor, and rub what remains to powder. Put this into another very shallow vessel; then apply a slow fire, and gradually increase it until red vapour ceases to rise.

The *Edinburgh College* directs of Mercury, ℥viij.; Diluted Nitric Acid (*D.* 1820) f℥v. Dissolve half of the mercury in the acid, with the aid of a moderate heat; and continue the heat till a dry salt is formed. Triturate the rest of the mercury with the salt till a fine uniform powder be obtained; heat the powder in a porcelain vessel, and constantly stir it till acid fumes cease to be discharged.

The *Dublin College* orders of purified Mercury, two parts; Diluted Nitric Acid, three parts. Let the mercury be dissolved, and let heat be applied until the dried mass passes into red scales.

This compound is best prepared on a large scale, for it cannot be so well procured of the bright orange-red colour, and crystalline or scaly appearance, usually considered desirable, when only small quantities of materials are employed. Some advise a larger quantity of nitric acid to be employed than is directed in the London Pharmacopœia. The reduction of the nitrate to powder is objectionable, as it diminishes the crystalline appearance of the oxide. Mr. Brande[3] says, "the nitrate requires to be constantly stirred during the process, which is usually performed in a cast-iron pot." But in general a shallow earthen dish is employed, with a second one inverted over it, and care is taken not to disturb the nitrate during the operation. The heat of the sand-bath is employed. Indeed, some have asserted that the finest product is obtained when the calcination is performed in the same vessel in which the nitrate was formed, and without stirring, as directed in the Dublin Pharmacopœia.[4]

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[1] Guibourt, *Journ. Chim. Méd.* iii. 377; also *Pharm. Raisonneé*, i. 563; and Soubeiran, *Nouv. Traité de Pharm.* ii. 529.

[2] *Brit. and For. Med. Rev.* April 1836.

[3] *Manual of Chemistry.*

[4] Dr. Barker, *Observ. on the Dublin Pharmacopœia.*

When quicksilver and the diluted nitric acid are digested together, the metal is oxidized at the expense of part of the acid, while binoxide of nitrogen escapes, and, combining with oxygen of the air, becomes nitrous acid. The oxidized metal unites to some undecomposed nitric acid to form a nitrate of the suboxide. $6Hg+4NO^5=NO^2+3(Hg^2O,NO^5)$.

When this nitrate is heated, decomposition takes place: the nitric acid yields oxygen to the suboxide of mercury, which thereby becomes red-oxide of mercury, while nitrous acid (or its elements) escapes. $Hg^2O,NO^5=2HgO+NO^4$.

Some pernitrate of mercury usually remains undecomposed, but the quantity is small. Mr. Brande states, that 100 pounds of mercury and 48 pounds of nitric acid (sp. gr. 1·48), yielded 112 pounds of nitric oxide of mercury. Hence three pounds of nitric acid must have remained in combination with the oxide.

PROPERTIES.—It occurs in bright tile-red, or scarlet, crystalline grains or scales. Dr. Barker[1] found that 1000 parts of water took up 0·62 of this oxide. The other properties and characteristics of this compound are the same as those of the last-mentioned preparation (see *hydrargyri oxydum rubrum*).

PURITY.—The presence of some undecomposed nitrate may be recognised by heating the suspected nitric oxide of mercury, when nitrous vapours are evolved, and by boiling in water, when a solution is obtained, from which lime water and hydrosulphuric acid throw down precipitates. The nitric oxide of mercury is completely dissipated by heat: hence the presence of non-volatile matters (as red lead) might be readily detected. Heated before the blow-pipe on charcoal, the mercurial oxide is reduced and dissipated, but if red lead be present, globules of metallic lead will be left behind.

On the application of heat no nitric vapour is emitted. Neither lime-water nor hydrosulphuric acid throws down any thing from the water in which it has been boiled. In other respects it resembles the preceding preparation.—*Ph. Lond.*

Entirely soluble in muriatic acid: heat decomposes and sublimes it entirely in metallic globules, without any discharge of nitrous fumes.—*Ph. Ed.*

PHYSIOLOGICAL EFFECTS.—Its local action is that of a powerful irritant (vide *hydrarggri oxydum rubrum*). But the presence of nitrate of mercury in the nitric oxide renders its topical action more energetic. Its constitutional effects are the same as those of other mercurials.

Fabricius Hildanus, Bartholinus, Langius, and Jacobs,[2] have reported cases in which the external use of this agent gave rise to salivation and other constitutional effects of mercury. In the case mentioned by Jacobs, death resulted from the application of it to a wart on the face.

Frederic Hoffman, Ploucquet, Girtanner,[3] and more recently Mr. Brett,[4] have related instances of poisoning by its internal employment.

USES.—Internally it has been administered in the form of pill in venereal diseases, but the practice is highly objectionable.

As an external agent it is used in the form of powder (obtained by levigation) or ointment; the latter is officinal. As a caustic, it is sprinkled over spongy excrescences, venereal warts, chancres, indolent fungous ulcers, &c. Mixed with eight parts of finely-powdered white sugar, it is blown into the eye with a quill in opacity of the cornea.[1]

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[1] *Op. cit.*

[2] Quoted by Wibmer, *Wirkung d. Arzneim.* iii. 69.

[3] Wibmer, *op. cit.*

[4] *Lond. Med. Gaz.* xiii. 117. A case of poisoning with it is also recorded in the *Lancet* for 1836-37, vol. i. p. 401.

UNGUENTUM HYDRARGYRI NITRICO-OXYDI, L.; *Unguentum Oxidi Hydrargyri,* E.; *Unguentum Hydrargyri Oxydi Nitrici,* D. (Finely-powdered Nitric Oxide of Mercury, ℥j.; White Wax, ℥j.; Lard, ℥vj. Mix. *L. D.*—The *Edinburgh College* employs Nitric Oxide of Mercury, ℥j.; Lard, ℥viij.)—This ointment undergoes decomposition by keeping; its colour changing from red to grey, in consequence of the partial deoxidation of the nitric oxide of mercury. Dr. Duncan[2] says the presence of resin quickly causes it to become black. It is a valuable stimulant, and is frequently applied to indolent sores and ulcers, when we require to increase the quantity, and improve the quality, of the discharge; to inflamed eye-lids (*ophthalmia tarsi*), chronic conjunctivitis, &c.

166. HYDRARGYRI SULPHURETUM.—SULPHURET OF MERCURY.

Formula HgS. *Equivalent Weight* 116.

Two forms of this compound are used in medicine, one crystallized or red, the other amorphous or black.

1. Hydrargyri Sulphuretum Crystallizatum vel Rubrum.—Crystallized or Red Sulphuret of Mercury.

History.—Crystallized or red sulphuret of mercury was known in the most ancient times. *Vermilion* is mentioned twice in the Old Testament;[3] Theophrastus[4] states that there are two kinds of cinnabar (*κιννάβαρι, cinnabaris*) one native, the other factitious; the first was sulphuret of mercury; the second, he says, was a scarlet sand.

Geiger[5] found it in the colouring matter of the old Egyptian tombs. It was formerly called *minium*.[6] It is sometimes termed *bisulphuret of mercury* (*hydrargyri bisulphuretum*).

Natural History. — The principal repositories of *native cinnabar* (*cinnabaris nativa*) are Idria, in Carniola, and Almaden, in Spain. It occurs both massive and crystallized; the primary form of its crystals being the acute rhombohedron.

Preparation.—All the British Colleges give directions for the preparation of this compound.

The *London College* orders of Mercury, lbij.; Sulphur, ℥v. Melt the sulphur, add the mercury, and continue the heat until the mixture begins to swell up. Then remove the vessel, and cover it closely to prevent the mixture taking fire. When the material is cold, reduce it [the mass] to powder, and sublime it.

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[1] Mackenzie, *On Diseases of the Eye*, 2d edit. p. 584.

[2] *Edinb. Dispensatory.*

[3] *Jeremiah*, xxii. 14; *Ezekiel*, xxiii. 14.

[4] *De Lapidibus*, p. 399, ed. Heins, 1613; Hill's translation, 2d edit. p. 227, 1774.

[5] *Handb. d. Pharm.* by Liebig.

[6] Pliny, *Hist. Nat.* lib. xxxiii. cap. 38, ed. Valp.

The process of the *Edinburgh College* is similar.

The *Dublin College* orders of Purified mercury, *nineteen parts;* Sublimed Sulphur, *three parts.* Mix the mercury with the melted sulphur, and, if the mixture takes fire, extinguish the flame by covering the vessel. Reduce the product of this operation to powder, and sublime it.

In this process the heat enables the mercury and sulphur to combine and form black or amorphous sulphuret of mercury. When large quantities of sulphur and mercury are heated together, a slight explosion and flame are produced. By sublimation the black sulphuret is converted into *cinnabar* or the red or crystallized sulphuret.[1]

PROPERTIES.—Artificial cinnabar has, in the mass, a dark reddish-brown crystalline appearance; but, when reduced to a fine powder, is of a beautiful scarlet-red colour, and is then termed *vermilion.* It is tasteless, odourless, insoluble in water or alcohol, and unalterable in the air. It is fusible and volatile. It burns in the air with a blue flame, the sulphur uniting with oxygen to form sulphurous acid, while the mercury is dissipated in a vaporous form.

Characteristics.—Heated in a glass tube, with potash, it evolves mercurial vapour, which condenses into liquid globules of this metal. The residue, which is sulphuret of potassium, gives out hydrosulphuric acid on the addition of hydrochloric acid. The colour of cinnabar deepens under the influence of heat.

COMPOSITION.—Its composition is as follows:—

	Atoms.	*Eq. Wt.*	*Per Cent.*	*Guibourt.*	*Sefström.*	*Erdmann and Marchand.*
Mercury	1	100	86·21	86·21	86·29	86·211
Sulphur	1	16	13·79	13·79	13·71	13·789
Sulphuret of Mercury	1	116	100·00	100·00	100·00	100·000

PURITY.—Pure cinnabar is totally evaporated by heat, and is insoluble in nitric or hydrochloric acid. If minium, or red lead, be intermixed, we may recognise it by boiling in acetic acid, by which acetate of lead is procured in solution: this forms a black precipitate with hydrosulphuric acid, white with the sulphates, and yellow with iodide of potassium. Realgar, or sulphuret of arsenicum, may be detected by boiling the suspected cinnabar in solution of caustic potash, supersaturating with nitric acid, and passing a current of hydrosulphuric acid through it, by which a yellow precipitate (AsS^3) is obtained. Earthy impurities are not volatile.

Totally evaporated by heat; and on potash being added to it, it runs into globules of mercury. It is not dissolved either by nitric or hydrochloric acid, but is so by a mixture of them. Rectified spirit, with which it has been boiled or washed, acquires no red colour. Digested with acetic acid it yields no yellow precipitate by iodide of potassium.—*Ph. Lond.*

"It is sublimed entirely by heat, and without any metallic globules being formed."—*Ph. Ed.*

PHYSIOLOGICAL EFFECTS.—According to Orfila,[2] pure cinnabar is inert; for he found no effects were produced on dogs by half an ounce when either applied to wounds or taken into the stomach. These results being opposite to those obtained by Smith,[1] it has been presumed that the latter must have employed an impure sulphuret.

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[1] Full details respecting the Dutch method of manufacturing cinnabar are given in the *Ann. de Chim.* iv. 25; and in Aikin's *Dict. of Chemistry,* vol. ii. p. 87.

[2] *Archiv. Gén. de Méd.* xix. 330.

The vapour obtained by heating cinnabar in the air is poisonous, but this is not in opposition to Orfila's experiments, since this vapour is not sulphuret of mercury, but a mixture of the vapour of mercury (either in the metallic or oxidized state) and of sulphurous acid gas. Schenkius[2] has related the case of a young man who died from the use of this vapour, and Hill[3] saw cough, violent salivation, diarrhœa, &c. produced by its inhalation.

Uses.—Cinnabar is used merely as a fumigating agent, in venereal ulcerations of the nose and throat. The method of using it is this:—About half a drachm is placed on a heated iron, and the fumes inhaled as they arise. In the shops, a copper apparatus, with iron heater, is sold for the purpose. In the absence of this, the sulphuret is to be placed on a hot iron shovel, and the vapour inhaled by the patient through a funnel. The irritating nature of the sulphurous vapour usually excites coughing, and is injurious in persons disposed to phthisis. Hence the oxide of mercury is to be preferred for fumigation.

Administration.—When employed internally, cinnabar has been given in doses of from ten grains to half a drachm. For the purpose of fumigation, half a drachm may be employed.

2. Hydrargyri Sulphuretum Nigrum vel Amorphum.—Amorphous or Black Sulphuret of Mercury.

History.—Amorphous sulphuret of mercury with excess of sulphur (*hydrargyri sulphuretum cum sulphure*), is commonly called *æthiops mineral* (*æthiops mineralis*), and is usually known in the shops as the *black sulphuret of mercury* (*hydrargyri sulphuretum nigrum*).

It is stated that the Chinese used it long before it was known to Europeans. Harris, in 1689, first taught the method of preparing it by trituration.

Preparation.—The London and Dublin Colleges give directions for the preparation of this compound.

The *London College* orders of Mercury; Sulphur, each, lbj. Rub them together, until globules are no longer visible.

The directions of the *Dublin College* are similar, with the addition that a stone-ware mortar should be used.

Properties.—It is a heavy, black, tasteless, odourless powder, insoluble in water. When heated, it fuses, and is completely dissipated.

Characteristics.—By boiling in caustic potash liquor, we obtain a solution of sulphuret of potassium. The residue is black, but possesses all the before-mentioned chemical characteristics of cinnabar.

Composition.—If this compound be, as Mr. Brande[4] supposes, a mixture of sulphuret of mercury and sulphur, the proportions must be—

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[1] Christison, *Treat. on Poisons*, 3d edit. 395.

[2] *Observ.* L. vii.

[3] *Edinb. Med. Essays*, iv.

[4] *Manual of Pharmacy*, 3d edit. 329.

	Per Cent.
Sulphuret of Mercury	58
Sulphur	42
Hydrargyri Sulphuretum cum Sulphure, *Ph. Lond.*	100

PURITY.—Free mercury may be detected by its communicating a white stain to gold. Charcoal may be detected by its not volatilizing by heat. Animal charcoal, by this character, as well as by the presence of phosphate of lime in the residue. Tersulphuret of antimony may be recognised by boiling in hydrochloric acid, and applying the before-mentioned tests for terchloride of antimony.

Totally evaporated by heat, no charcoal nor phosphate of lime being left.—*Ph. Lond.*

PHYSIOLOGICAL EFFECTS.—According to the experiments of Orfila, this preparation, like the last, possesses little or no activity. The late Dr. Duncan[1] also tells us that he has given it in doses of several drachms for a considerable length of time with scarcely any effect. It is commonly regarded as alterative.

USES.—It has been used in glandular diseases, especially of children, and also in cutaneous diseases.

ADMINISTRATION.—The dose for adults is from 5 to 30 grains.

167. HYDRARGYRI SULPHATES.—SULPHATES OF MERCURY.

There are probably four compounds of sulphuric acid with the oxides of mercury.

Sulphate of the Suboxide of Mercury	Hg^2O,SO^3
Tribasic Sulphate of the Oxide of Mercury	$3HgO,SO^3$
Sulphate of the Oxide of Mercury	HgO,SO^3
Supersulphate of the Oxide of Mercury	HgO,xSO^3 (?)

Of these, two only will require separate notice here—namely, the second and third.

1. Hydrargyri Subsulphas Flavus.—Yellow Subsulphate of Mercury.

Formula $3HgO,SO^3$. *Equivalent Weight* 364.

HISTORY.—This compound was known to Croll in the sixteenth century. It has been termed *turpeth* (or *turbith*) *mineral* (*turpethum minerale*), from its resemblance in colour or action to the root of the *Ipomœa Turpethum.* It has been known by various other names; as the *tribasic sulphate of the oxide* (or peroxide) *of mercury,* the *subpersulphate of mercury,* or the *hydrargyri oxydum sulphuricum.*

PREPARATION.—The *Dublin College* directs it to be thus prepared:—

Take of the Persulphate of Mercury one part, Warm Water twenty parts. Triturate them together in an earthenware mortar, and pour off the supernatant liquor; let the yellow powder be washed with distilled water, so long as the decanted fluid exhibits any deposit on the addition of some drops of the water of caustic potash; lastly, let the sulphuric oxide of mercury be dried.

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[1] *Edinburgh Dispensatory.*

By the action of water there are obtained a soluble supersulphate and a difficultly-soluble subsulphate of mercury.

PROPERTIES.—It is a heavy, lemon-yellow, inodorous powder, having an acrid taste. It requires 2000 parts of water at 60°, or 600 parts at 212°, to dissolve it.

Characteristics.—When heated in a tube, sulphurous acid is evolved, and globules of mercury sublimed. Boiled with caustic potash or soda, the red or peroxide precipitates, and a solution of sulphate of potash is obtained, known to be a sulphate by chloride of barium.

COMPOSITION.—Its composition is as follows :—

	Atoms.	*Eq. Wt.*	*Per Cent.*	*Kane.*	*Geiseler.*
Oxide (or Peroxide) of Mercury	3	324	89·01	88·90	88·41
Sulphuric Acid	1	40	10·99	10·95	11·34
Yellow Subsulphate of Mercury	1	364	100·00	99·85	99·75

PHYSIOLOGICAL EFFECTS.—In small quantities it occasions nausea, vomiting, and ptyalism. Taken into the nostrils, it excites sneezing, and sometimes salivation. Stenzel[1] mentions a fatal case from its internal use.

USES.—It is sometimes used as an emetic in cases of swelled testicle, to promote absorption by its nauseating and emetic action.[2] It was formerly given at the commencement of a mercurial course. As an errhine, it has been administered in chronic ophthalmia and affections of the brain—as incipient hydrocephalus. As an alterative, it has been given in the scaly diseases (lepra and psoriasis).

ADMINISTRATION.—As an alterative, the dose should not exceed half a grain, or at most a grain. As an emetic, it is given to the extent of five grains, in which dose it causes violent vomiting. As an errhine, a grain should be mixed with four or five of some mild powder, as starch or liquorice powder. It is rarely given for any other purposes.

2. Hydrargyri Persulphas.—Persulphate of Mercury.

Formula HgO,SO^3. *Equivalent Weight* 148.

Sulphate of the Peroxide of Mercury; Bipersulphate of Mercury. This preparation is not used in medicine either as an internal or external remedy; but in pharmacy it serves for the preparation of several other mercurial compounds; as calomel, corrosive sublimate, and subsulphate of mercury.

The *Dublin College* gives the following formula for its preparation :—

Take of Purified Mercury; Sulphuric Acid, of each, *six parts;* Nitric Acid, *one part.* Let them be exposed to heat in a glass vessel, and let the fire be increased until the thoroughly dried residue shall have become white.

In this process the nitric acid serves to oxidize the mercury, and the oxide thus produced combines with sulphuric acid $3Hg+NO^5+3SO^3=3(HgO,SO^3)+NO^2$.

The *London* and *Edinburgh Colleges* give directions for the preparation of this compound, in the processes for the manufacture of calomel and corrosive sublimate.

This salt is an opaque, white solid. It becomes orange-coloured at a dull red heat, but white on cooling: at a full red heat it is decomposed. It is decomposed by water, which resolves it into a basic salt (turpeth mineral) and a supersalt.

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[1] Wibmer, *Wirk. d. Arzneim.* iii. 66.

[2] Barker, *Observ. on the Dublin Pharmacopœia.*

168. HYDRARGYRI SUBCHLORIDUM.—SUBCHLORIDE OF MERCURY OR CALOMEL.

Formula Hg^2,Cl. *Equivalent Weight* 235·5.

HISTORY.—Beguin in 1608, and Oswald Croll in 1609, are the first Europeans who mention this compound. Mr. Hatchett[1] says it had been long known to the natives of Thibet. Its discoverer is unknown. It has had a great variety of names. The term *calomel* (*calomelas*, from καλὸς, *good*, and μέλας, *black*) was first used by Sir Theodore Turquet de Mayenne[2] (who died in 1655), in consequence, as some say, of his having had a favourite black servant who prepared it; or, according to others, because it was a *good* remedy for the *black* bile. *Drago mitigatus*, *aquila alba*, *manna metallorum*, and *panchymagogum minerale*, are some of the appellations for it. *Mercurius dulcis*, *hydrargyrum muriaticum mite*, *submuriate of mercury*, and *chloride*, *subchloride*, or *protochloride of mercury*, are some of the more modern synonymes of it.

One of the inconveniences attending the alteration of the atomic weight is, that the name (*chloride of mercury*), formerly applied to calomel, is now transferred to corrosive sublimate. This is one of the evils necessarily attendant on the adoption of scientific language in pharmacy.

NATURAL HISTORY.—*Native calomel*, or *corneous mercury*, occurs in crusts, and also crystallized in four-sided prisms terminated by pyramids. It is found at Deux-Ponts, Carniola, and in Spain.

PREPARATION.—All the British Colleges give directions for the preparation of this salt.

The *London College* orders of Mercury, lbiv.; Sulphuric Acid, lbiij.; Chloride of Sodium, lbiss.; Distilled Water, as much as may be sufficient. Boil two pounds of the Mercury with the Sulphuric Acid in a proper vessel, until the Bipersulphate of Mercury remains dry; rub this when it is cold with (the remaining) two pounds of Mercury in an earthen mortar, that they may be perfectly mixed. Afterwards add the Chloride of Sodium, and rub them together, until globules are no longer visible; then sublime. Rub the sublimate to very fine powder, and wash it carefully with boiling distilled water, and dry it.

The *Edinburgh College* directs of Mercury, ℥viij.; Sulphuric Acid (commercial) f℥ij. and fʒiij.; Pure Nitric Acid, f℥ss.; Muriate of Soda, ℥iij. Mix the Acids, add four ounces of the mercury, and dissolve it with the aid of a moderate heat. Raise the heat so as to attain a dry salt. Triturate this with the Muriate of Soda and the rest of Mercury till the globules entirely disappear. Heat the mixture by means of a sand-bath in a proper subliming apparatus. Reduce the sublimate to fine powder; wash the powder with boiling distilled water until the water ceases to precipitate with solution of iodide of potassium; and then dry it.

The *Dublin College* direct sublimed calomel (*calomel sublimatum*) to be prepared as follows from the persulphate of mercury, the formula for the preparation of which has already been given (see *ante*, p. 846).

Take of Persulphate of Mercury, *twenty five parts*; Purified Mercury, *seventeen parts*; Dried Muriate of Soda, *ten parts*. Let the Persulphate of Mercury and purified Mercury be triturated together in an earthenware mortar, until the metallic globules shall have completely disappeared; then let the dried Muriate of Soda be added: let them be well mixed, and in a suitable vessel, with a heat gradually raised, let them be sublimed into a receiver; let the sublimed mass be reduced to powder, and washed with water, so long as the decanted liquor, on addition of water of Caustic Potash, shall exhibit any deposition; lastly, let the sublimed calomel be dried.

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[1] Brande's *Manual of Pharmacy*, 2d edit. 328.

[2] *Annals of Philosophy*, vol. ii. N. S. p. 427. See also the old series of this journal, vol. xvi. pp. 309, 39[illegible], and [illegible]6.

The theory of the production of persulphate of mercury by the joint action of nitric and sulphuric acids on mercury, as directed by both the Edinburgh and Dublin Colleges, has been before explained (see *ante*, p. 846).

The London College directs the persulphate to be prepared by the action of oil of vitriol on mercury. One equivalent of mercury decomposes an equivalent of sulphuric acid, and abstracts an equivalent of oxygen, to form one equivalent of oxide of mercury, disengaging an equivalent of sulphurous acid. The oxide combines with an equivalent of undecomposed sulphuric acid, and forms one equivalent of persulphate of mercury. $Hg+2SO^3=HgO,SO^3+SO^2$.

When one equivalent of persulphate of mercury, one of metallic mercury, and one of chloride of sodium, are intimately mixed and sublimed, the products are one equivalent of sulphate of soda and one of calomel. $HgO,SO^3+Hg+NaCl=Hg^2Cl+NaO,SO^3$.

At Apothecaries' Hall, 50 lbs. of mercury are boiled with 70 lbs. of sulphuric acid to dryness in a cast-iron vessel; 62 lbs. of the dry salt are triturated with 40½ lbs. of mercury until the globules disappear; and 34 lbs. of common salt are then added. The mixture is submitted to heat, and from 95 to 100 lbs. of sublimed calomel are obtained. It is washed in large quantities of distilled water after having been ground to a fine and impalpable powder.

The subliming apparatus varies in different manufactories. In some it consists of a large earthen retort, with short but wide neck, opening into an earthen elliptical receiver, in the bottom of which is water. The retort is placed in sand contained in an iron pot set in a furnace.

"The form in which calomel sublimes," observes Mr. Brande, "depends much upon the dimensions and temperature of the subliming vessels. In small vessels it generally condenses in a crystalline cake, the interior surface of which is often covered with beautiful quadrangular prismatic crystals,[1] transparent, and of a texture somewhat elastic or horny: in this state it acquires, by the necessary rubbing into powder, a decidedly yellow or buff colour, more or less deep, according to the degree of trituration which it has undergone. If, on the contrary, the calomel be sublimed into a very capacious and cold receiver, it falls in a most impalpable and perfectly white powder, which requires only one elutriation to fit it for use; it then remains perfectly colourless. By a modification of the process, it may be suffered, as it sublimes, to fall into water, according to Mr. Jewell's patent.

"The above circumstances, too, account for the various appearances under which calomel occasionally presents itself in commerce: it may be added that the buff aspect of this substance indicates the absence of corrosive sublimate, though it by no means follows as a consequence that when snow-white it contains it. When the surface of massive sublimed calomel is scratched, it always exhibits a buff colour: it also becomes yellow when heated, but loses its tint as it again cools."[2]

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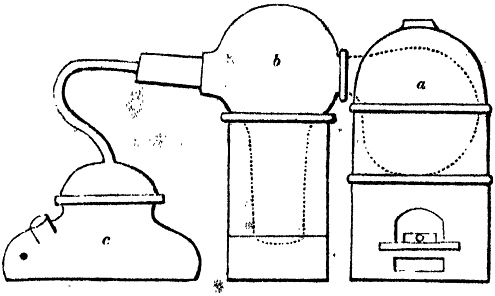
[1] Brooke, *Annals of Philosophy*.

[2] *Manual of Chemistry*, 4th edit. p. 788.

Mr. Jewell's process[1] for preparing calomel consists in vessel filled with steam, so that the vaporous calomel is condensed in it, and takes the form of a fine powder, which is much finer than can be obtained by levigation and elutriation. This process has been improved by M. O. Henry (fig. 141).

Soubeiran[2] has proposed to modify this process, by substituting a current of air for the vapour of water; a modification which Mr. Calvert[3] states is identical with that already in use in some manufacturing houses in England. The apparatus is an iron cylinder closed at one extremity by a door through which the materials are introduced: the other extremity has a kind of neck attached to it.

FIG. 140.



Henry's modification of Jewell's apparatus for preparing calomel by steam (hydrosublimate of mercury).

a. Furnace, containing an earthen retort (having a wide and short neck), in which the ingredients for making calomel are placed.

b. An earthen receiver, having three tubulures: one communicating with the retort, a second dipping into water in an earthen jar, and a third connected to a steam-pipe.

c. Steam-boiler.

2. Another method of preparing calomel is by precipitation.

The *Dublin College* directs precipitated calomel (*calomelas præcipitatum*, D.) to be thus prepared:—

Take of Purified Mercury, *seventeen parts*; diluted Nitric acid, *fifteen parts*. On the mercury passed into a glass vessel, pour the acid, and when the mixture shall have ceased to effervesce, digest with a *medium* heat [between 100° and 200° F.] during six hours, occasionally stirring it; then let the heat be increased that the liquor may boil for a short time, and let this be poured off from the residual mercury, and quickly mixed with four hundred parts of boiling water containing seven parts of muriate of soda in solution. Let the powder which falls down be washed with warm water, so long as the decanted liquor, on addition of some drops of water of caustic potash, shall form any deposit: lastly, let it be dried.

By the mutual reaction of mercury and diluted nitric acid, the suboxide of mercury is formed; binoxide of nitrogen gas being evolved. When solutions of nitrate of suboxide of mercury and of chloride of sodium are mixed, double decomposition takes place; nitrate of soda is formed in solution, while dichloride of mercury, or calomel, is precipitated. "If this process be carefully performed, and the precipitate thoroughly edulcorated, the calomel is said to be sufficiently pure; but a small portion of chloride of sodium is apt to remain combined with it, which might affect its medical uses." (Brande.)

3. Dr. A. T. Thomson[4] has taken out a patent for the formation of both calomel and corrosive sublimate, by the direct union of chlorine gas and the vapour of mercury.

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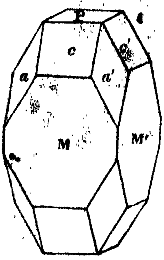
[1] *Repert. of Arts.* xiii. 79, 2d series.

[2] *Chemical Gazette*, vol. i. p. 210, 1843.

[3] *Ibid.* vol. i. p. 270, 1843.

[4] *Ibid.* vol. i. p. 223, 1843.

FIG. 141.



Crystal of Calomel.

PROPERTIES.—The crystals of calomel are square prisms. The appearance of the crystalline cake of sublimed calomel has been already noticed. As met with in the shops, it is in the form of a fine odourless and tasteless powder, whose specific gravity is 7·140 (Boullay), 7·156 (Pelouze and Fremy). When prepared by Jewell's process it is perfectly white, but, when obtained in the ordinary way, it has a light buff or ivory tint. It volatilizes by heat, and, under pressure, fuses. It is insoluble in cold water and alcohol. According to Donovan[1] and others,[2] calomel suffers partial decomposition by long boiling in water, and a solution is obtained which contains mercury and chlorine (corrosive sublimate?).

By exposure to light, calomel becomes dark coloured, in consequence, according to Dumas,[3] of the transformation of a small portion into mercury and corrosive sublimate. Others have ascribed this change to the evolution of chlorine and combination of the metal with oxygen. Both hypotheses are inconsistent with the statement of Vogel,[4] that this blackened calomel is insoluble in nitric acid. Is it not probable that the change depends on the formation of a subchloride (Hg^4Cl?), as Wetzlar has shewn to be the case with chloride of silver? By digestion in hot and concentrated hydrochloric acid, we obtain perchloride of mercury and reguline mercury. Boiling sulphuric acid forms persulphate and perchloride of mercury, with the evolution of sulphurous acid. When calomel absorbs dry ammonia, it forms a dark grey powder, which is $2Hg^2Cl,NH^3 = 2Hg^2Cl,HAd$. (Kane.) But if calomel be digested in water of ammonia, one-half of its chlorine is converted into sal ammoniac and a dark grey powder (called by Kane *black precipitate*) results, which is a compound of subchloride and subamidide of mercury; $Hg^2Cl + Hg^2Ad$.

Characteristics.—Heated in a glass tube by a spirit lamp it is volatilized, and yields a white sublimate.

Mixed with soda-flux, and heated, it yields a sublimate of metallic liquid globules (see *ante*, p. 811): thus showing it to be a mercurial compound.

By the action of lime-water it yields a blackish grey precipitate (Hg^2O): if to the supernatant liquor an excess of nitric acid be added, there is obtained, on the addition of nitrate of silver, a white precipitate (AgCl).

Protochloride of tin decomposes it: the products are bichloride of tin and globules of metallic mercury.

COMPOSITION.—The following is the composition of calomel:—

	Atoms.	*Eq. Wt.*	*Per Cent.*	*Turner, Davy, Zaboada.*
Mercury	2	2000	84·92	85
Chlorine	1	35·5	15·08	15
Subchloride of Mercury	1	235·5	100·00	100

	Vols.	*Sp. Gr.*
Mercurial Vapour	1	6·976
Chlorine Gas	½	1·237
Vapour of Calomel	1	8·213

PURITY.—When pure, calomel is completely vaporized by heat. Water or alcohol which has been digested on it, should occasion no precipitate or change of colour on the addition of lime-water, caustic potash, ammonia, nitrate of silver, or hydrosulphuric acid, by which the absence of perchloride of mercury may be inferred. I have met with calomel which, in consequence of being imperfectly washed, contained corrosive sublimate. It had been given to several patients before its purity was suspected, and had operated on them most violently. When mixed with potash it became black, like pure calomel: the quantity of sublimate being insufficient to produce any perceptible alteration in the colour of the precipitate. But water which had been digested on it, gave, with the above-mentioned tests, the characteristic indications of perchloride of mercury.

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[1] *Ann. Phil.* xiv. 323.

[2] Gmelin, *Handb. d. Chemie*, i. 1299; Geiger's *Handb. d Pharm.* by Liebig, i. 561.

[3] *Traité de Chimie*, iii. 605.

[4] Langrebe, *Ueber das Licht*, 87.

A whitish powder, which, on the addition of potash, becomes black, and then, when heated, runs into globules of mercury. It is also totally vapourized by heat. The distilled water with which it has been washed, or in which it has been boiled, gives no precipitate with nitrate of silver, lime-water, nor hydrosulphuric acid.—*Ph. Lond.*

Heat sublimes it without any residuum: sulphuric ether agitated with it, filtered, and then evaporated to dryness, leaves no crystalline residuum. and what residuum may be left is not turned yellow with aqua potassæ—*Ph. Ed.*

PHYSIOLOGICAL EFFECTS. α. *On Animals.*—Wepfer,[1] Viborg, Flormann,[2] Gaspard,[3] and Annesley,[4] have examined the effects of calomel on dogs, horses, and pigs, but without any remarkable results. Viborg gave half an ounce, with six pounds of water, to a horse: the effects were cough, heaving of the flanks, quick pulse, enfeebled appetite, and in twenty-four hours loose stools. Annesley asserts, from his experiments on dogs, that large doses of calomel diminish the vascularity of the gastro-intestinal membrane.

β. *On Man.*—Calomel may be ranked among the milder preparations of mercury; for although, in its local action, it is somewhat more powerful than the oxide, or than those preparations which contain mercury in a finely-divided state (as blue pill), yet it is milder than most of the other salts of mercury. Introduced into the stomach through a permanent artificial opening caused by a gun-shot wound, Dr. Beaumont found that twelve grains of calomel caused commotion, slight nausea, and the secretion of a white frothy fluid running at the aperture like fermenting beer from a bottle.[5] Swallowed in *small doses*, as a few grains, it occasionally excites no obvious effects, though more commonly it acts as a purgative; and in very susceptible persons, especially females, it sometimes produces nausea, griping, and great faintness. It appears from the experience of most practitioners that adults are more susceptible of the influence of calomel than children.[6] The green stools (called *calomel stools*) which sometimes follow the administration of calomel to children, are usually supposed to arise from the action of this medicine on the liver; though Zeller (quoted by Kraus) thinks it depends on alterations produced in the condition of the blood; and Kraus[1] is disposed to refer it to the operation of calomel on the milk contained in the alimentary canal.[2] But the same coloured stools are frequently observed when no mercury has been used, and there does not appear to me to be any just ground for ascribing them to the calomel.[3] Like other mercurials, it increases the action of the secreting organs, and thus promotes the secretion of bile and of intestinal mucus; and we also presume it has a similar influence over the secretion of the pancreatic fluid. Neumann[4] states that a man took two, then three, and subsequently four grains of calomel, daily, for the space of two months without inducing salivation; but three months afterwards he became affected with chronic vomiting, the consequence of a scirrhous pancreas, of which he died in four months. From the manner in which the case is related, it is clear the narrator attributed the disease of the pancreas to the use of mercury; whether justly or not, however, it is impossible to determine.

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[1] *Hist. Cicutæ Aquat.*

[2] Wibmer, *Wirk d. Arzn.*

[3] Magendie, *Journ de Physiol.*

[4] *Diseases of India.*

[5] *Experiments and Observations on the Gastric Juice and the Physiology of Digestion*, p. 182. Edinb. 1838.

[6] To this statement exceptions are frequently observed. The following is an instance of the occasional violence of the action of calomel on children. The late Dr. Thomas Davies attended, with the late Mr. Edwin Quekett, a boy of four years of age, labouring under peritonitis. One grain of calomel was directed to be administered three times a day; and an aperient dose of calomel and jalap was given. On the fourth day its employment was stopped, in consequence of its violent action. The cheeks were enormously swollen, the gums sloughed, necrosis of the alveolar process of the lower jaw on each side occurred, and portions of bone, with the teeth, came away. The child ultimately recovered in about twelve months; but the jaws cannot be separated, and the patient is now obliged to suck his food through the apertures left by the loss of bone.

The repeated and continued use of calomel, in small doses, is attended with the constitutional effects of mercurial preparations generally, before described.

In *large doses*, it has been regarded as an irritant poison; and, judging from the fatal effects ascribed to it by several writers, not without reason. Thus Hellweg[5] has reported a case in which a few grains of calomel, taken as a laxative, caused death; Vagnitius[6] saw fifteen grains prove fatal; and Ledelius,[7] half an ounce. Fr. Hoffman has also related two fatal cases.[8]

"Whytt, Odier, Quin, Wibmer, Leib, and others," says Gölis,[9] "gave calomel internally in far larger doses; as two, three, and more grains, at a time; and continued its use many days in the same dose, without considering the many evacuations from the alimentary canal, or the violent colic pains; and they affirm that they have never remarked, from the effect of this agent given in these large doses, any bad consequences in the abdomen. Melancholy experience compels me to contradict them. Many times I saw, under those large and long-continued doses of calomel, the hydrocephalic symptoms suddenly vanish, and inflammation of the intestines arise, which terminated in death. Still oftener I observed this unfavourable accident from an incautious use of calomel in croup: namely, where all the frightful symptoms of this tracheal inflammation, which threatened suffocation, suddenly vanish, and enteritis develope itself, which passed rapidly into gangrene, and destroyed the patients."

In the *Times* newspaper of the 26th April, 1836, there is the report of a coroner's inquest on the body of a Mrs. Corbyn, who was destroyed by swallowing 20 grains of calomel, she having previously taken a moderate dose without it exciting what she considered a sufficient effect; and in the *India Journal of Medical Science*[1] is the case of a lad, aged 14, a native of Nepal, in whom six grains of calomel apparently produced inflammation and ulceration of the mouth, enormous swelling of the face, mercurial fœtor of the breath, mortification, and death. There was no ptyalism.

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[1] *Heilmittellehre*, 161.

[2] See also a paper *On the Effects of Calomel in producing Slimy Stools*, in the *Lond. Med. and Surg. Journ.* April 1829, p. 344.

[3] The so-called *calomel stools* have been analysed both by Simon (*Animal Chemistry*, vol. ii. p. 386) and by Dr. Golding Bird (*Ibid*; also *Lond. Med. Gaz.* Sept. 5, 1845): the results furnish no evidence of the supposed calomel origin of the stools. No mercury was recognised in them: Simon expressly states, that his attempts to detect mercury proved unsuccessful. These negative results favour the opinion given in the text, that the green colour of the stools is not dependent on the calomel.

[4] Gräfe and Walther's *Journal*, Bd. ii. H.3, S. 432, quoted by G. A. Richter, *Ausführ. Arzneim.* v. 492.

[5] Wibmer, *Op. cit.* iii. 71.

[6] *Ibid.*

[7] *Ibid.*

[8] *Ibid.*

[9] *Treatise on the Hydrocephalus Acutus*, by Dr. Gooch

In Pierer's *Annalen* for April 1827[2] is the case of a lady, who by mistake swallowed 14 drachms of calomel at once. Acute pains in the abdomen came on, accompanied by frequent vomiting and purging. These symptoms were allayed by oleaginous demulcents: but, on the second day, salivation and ulceration of the mouth took place. In three weeks, however, she was perfectly recovered. Other violent effects are noticed by Wibmer, Gmelin, and others; but the instances adduced are sufficient to show that dangerous and even fatal effects may result from large doses, and therefore that Teichmeyer, Buchner, and others, are justified in ranking it among poisons.

Of late years, however, immense quantities of calomel have been administered medicinally, without giving rise to any symptoms of irritant poisoning, —nay, apparently with the opposite effect; for we have the concurrent testimony of many practitioners, that in yellow fever, cholera, and other dangerous diseases, calomel, in doses of a scruple and upwards, allays vomiting and purging; and on this account has been denominated a *sedative*. So that while in small doses (as from two or five grains) calomel is almost universally admitted to be an irritant to the bowels, it is asserted that larger ones are actually sedative. These statements appear to me to be almost inconsistent, and yet they are fair deductions from the experience of numerous intelligent practitioners. We must, therefore, endeavour to accumulate more facts, in order to illustrate the effects of calomel, and for the present confess we have very imperfect information respecting the nature of its action.

In a case published by Mr. Roberts,[3] an ounce of calomel was swallowed by mistake, and retained on the stomach for two hours before the error was discovered. The only effects were slight nausea and faintness. Subsequently, emetics, lime-water, and purgatives, were administered; calomel was vomited up, and the day but one afterwards the patient was quite well. Neither salivation nor the slightest affection of the gums occurred.

The largest quantity of calomel given as a medicinal agent, at one dose, is, I believe, three drachms; "and it was followed," says Dr. Christison,[4] from whom I quote the case, which occurred in America, "by only one copious evacuation, and that not till after the use of an injection." I have now before me reports of eighteen cases of spasmodic cholera, admitted in the year 1832 into the Cholera Hospital at Bethnal Green, in this metropolis, in which enormous quantities of calomel were employed by the house-surgeon, Mr. Charles Bennett (formerly one of my pupils), with very slight physiological effects. When a patient was brought into the hospital, two drachms of calomel were immediately given, and afterwards one drachm every one or two hours, until some effect was produced. In 17 out of 18 cases in which this plan was tried, the vomiting and purging diminished, and the patients recovered. Several of them took from 20 to 30 drachms without the subsequent ptyalism being at all excessive. In one case (a female, aged 36 years), 30⅓ drachms were administered within forty-eight hours; moderate ptyalism took place, and recovery. In the unsuccessful case which I have alluded to, 53 drachms of calomel were administered within forty-two hours, without the least sensible effect.

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[1] *Lond. Med. Gaz.* xviii. 484.

[2] Quoted by Wibmer, *op cit.* 72.

[3] *Lond. Med. Gaz.* xxii. 611.

[4] *Treatise on Poisons.*

Dr. Griffin[1] also tells us, that in several cases of cholera he gave calomel hourly, "in scruple doses, to the amount of two or three drachms or upwards, without eventual salivation; and I recollect," he adds, "one instance in particular, in which I gave two drachms within an hour and a half with perfect success, and without affecting the system."

I do not pretend to reconcile these cases with those recorded by Hellweg, Vagnitius, Ledelius, Hoffman, and Gölis; in fact, they appear to me irreconcilable. Dr. Christison, however, suggests that in those cases in which violent effects occurred, the calomel might contain corrosive sublimate.

Mr. Annesley[2] accounts for the increased quantity of bile found in the stools after the use of calomel, by supposing that the gall-bladder sometimes becomes distended in consequence of the tenacity of the mucous secretion, by which the mouth of the *ductus communis choledochus* is closed; and that calomel acts chemically on the mucus, and detaches it. But the hypothesis is, I think, devoid of foundation.

USES.—Calomel is very frequently used as an *alterative*, in glandular affections, chronic skin diseases, and disordered conditions of the digestive organs, more particularly in those cases connected with hepatic derangement. For this purpose it is usually taken in combination with other alteratives, as in the well-known Plummer's pill, which I shall presently notice.

It is very frequently employed as a *purgative*, though on account of the uncertainty of its cathartic effects, it is seldom given alone; generally in combination with other drastic purgatives—such as jalap, scammony, compound extract of colocynth, &c. whose activity it very much promotes. We employ it for this purpose when we are desirous of relieving affections of other organs, on the principle of counter-irritation. Thus in threatened apoplexy, in mental disorders,[3] in dropsical affections, and in chronic diseases of the skin. In torpid conditions of the bowels, where it is necessary to use powerful cathartics to produce alvine evacuations, as in paralytic affections, it is advantageously combined with other purgatives. Sometimes we use it to promote the biliary secretion—as in jaundice and other affections of the liver, in chronic skin diseases, and in various disordered conditions of the alimentary canal not accompanied by inflammation. Moreover, in the various diseases of children requiring the use of purgatives, it is generally considered to be very useful; and its being devoid of taste is of course an advantage.

As a *sedative* it has been administered in yellow fever, spasmodic or malignant cholera, dysentery, and liver affections. Dr. Griffin[4] asserts that calomel proved a most successful medicine in cholera, controlling or arresting its progress in 84 cases out of 100, when administered while the pulse was perceptible at the wrist; but that, on the contrary, it proved detrimental when given in collapse. The practice was tested in 1,448 cases. The dose was from one to two scruples every hour or half-hour.

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[1] *Lond. Med. Gaz.* xviii. 880.

[2] *Diseases of India.*

[3] *Lond. Med. Gaz.* iii. 692.

[4] *Ibid.* xxi. 880.

As a *sialogogue*, it may be used in the cases in which I have already stated that mercurials generally are employed: with the view of preventing irritation of the alimentary canal, it is usually given in combination with opium, unless the existence of some affection of the nervous system contra-indicates the use of narcotics. This combination is employed in peripneumonia, pleuritis, croup, laryngitis, hepatitis, enteritis, and other inflammatory diseases: in fever, syphilis, chronic visceral diseases, &c.

Calomel is frequently combined with other medicines, to increase their effects; as with squills, to produce *diuresis*, in dropsy; or with antimonials, to promote *diaphoresis*.

As an *anthelmintic* it is in frequent use, and forms one of the active ingredients of many of the nostrums sold for worms; though it does not appear to have any specific influence over parasitic animals.

The *local uses* of calomel are numerous. In diseases of the Schneiderian membrane, it is applied as a snuff. It is sometimes blown into the eye, to remove spots on the cornea. Dr. Fricke[1] has used it with great success in chronic cases of rheumatic, catarrhal. and scrofulous ophthalmia; but in two instances bad consequences resulted from its use. It is sometimes suspended in thick mucilage, and used as a gargle in venereal sore-throat, or injected into the urethra in blennorrhœa. Now and then it is used as a substitute for cinnabar in fumigation. As a local application, in the form of ointment, calomel is one of the most useful remedies we possess for the cure of several forms of chronic skin diseases.

ADMINISTRATION.—When used as an *alterative*, it is given in doses of from half a grain to a grain, frequently combined with oxysulphuret of antimony (as in *Plummer's Pill*) or antimonial powder, and repeated every, or every other night; a mild saline laxative being given the following morning. As a *purgative*, from two to five grains are given usually in combination with, or followed by, the use of other purgatives, especially jalap, senna, scammony, or colocynth. As a *sialogogue*, it is exhibited in doses of one to three or four grains, generally combined with opium or Dover's powder, twice or thrice a day. As a *sedative*, the dose is from a scruple to half a drachm or more. Biett[2] has sometimes employed it as an *errhine*, in syphilitic eruptions. It is mixed with some inert powder, and given to the extent of from 8 to 20 grains daily. The use of acids with calomel frequently occasions griping. Calomel is most extensively employed in the diseases of children, and may be given to them in as large or proportionally larger doses than to adults. Salivation is a rare occurrence in them: indeed, Mr. Colles[3] asserts, that mercury *never* produces ptyalism, or swelling or ulceration of the gums, in infants; but this is an error (see *ante*, p. 851).

1. PILULÆ HYDRARGYRI CHLORIDI COMPOSITÆ, L.; *Pilulæ Calomelanos compositæ*, E. D.; *Compound Calomel Pills*. (Calomel; Oxysulphuret of Antimony, each ʒij.; Guaiacum, powdered, ℥ss.; Treacle, ʒij. Rub the Calomel with the Oxysulphuret of Antimony, afterwards with the

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[1] *Lond. Med. Gaz.* xxii. 397.

[2] *Ibid.* viii. 540.

[3] *Pract. Observ.* 281.

Guaiacum and the Treacle, until incorporated, *L.*—The *Edinburgh College* uses of Calomel, and Golden Sulphuret of Antimony, of each, *one part;* Guaiac, in fine powder, and Treacle, of each, *two parts;* the pill-mass is ordered to be divided into six-grain pills.—The *Dublin College* employs of Calomel, Brown Antimoniated Sulphur, of each, ʒj.; Guaiac, in powder, ʒij.; Treacle, as much as may be sufficient).—This compound is commonly known as *Plummer's pill* (*pilulæ Plummeri*) having been admitted into the Edinburgh Pharmacopœia at his recommendation. Calomel and precipitated tersulphuretum of antimony mutually but slowly react on each other; and the ultimate products are sulphuret of mercury and terchloride of antimony. In the dry state, and mixed with other ingredients, this change is retarded. These pills are frequently employed as alteratives in chronic skin diseases, in the papular and pustular forms of the venereal disease, in chronic liver affections, and in various disordered conditions of the digestive organs. The dose is from five to ten grains.

2. **PILULÆ CALOMELANOS ET OPII**, E.; *Calomel and Opium Pills.* (Calomel, *three parts;* Opium, *one part;* Conserve of Red Roses, *a sufficiency.* Beat them into a proper mass, which is to be divided into pills, each containing two grains of calomel).—Each pill contains two-thirds of a grain of opium. It is a valuable compound in rheumatism and various other inflammatory diseases. Dose one or two pills. If ptyalism be required, one pill may be repeated three times daily.

3. **UNGUENTUM HYDRARGYRI CHLORIDI**; *Calomel Ointment.* (Calomel, ʒj.; Lard, ℥j.)—This is a most valuable application in porrigo favosa, impetigo, herpes, and the scaly diseases (psoriasis and lepra). Indeed, if I were required to name a local agent pre-eminently useful in skin diseases generally, I should fix on this. It is well deserving a place in the Pharmacopœia.

4. **PILULÆ CATHARTICÆ COMPOSITÆ**, Ph. of the United States. *Compound Cathartic Pills.* (Compound Extract of Colocynth, ℥ss.; Extract of Jalap, in powder; Calomel, of each, ʒiij.; Gamboge, in powder, ℈ij. M. Divide into 180 pills).—This pill is intended to combine smallness of bulk with efficiency and comparative mildness of purgative action, and a peculiar tendency to the biliary organs.[1] Each pill contains one grain of calomel. Three pills are a full dose.

169. HYDRARGYRI PERCHLORIDUM.—PERCHLORIDE OF MERCURY.

Formula $HgCl$. *Equivalent Weight* 135·5.

HISTORY.—We have no account of the discovery of this preparation. Geber[2] described the method of preparing it; but it is supposed to have been known long anterior to him. Like calomel, it has had various synonymes, of which the principal are the following:—*chloride, bichloride, hydrochlorate, muriate* or *oxymuriate of mercury* (*hydrargyri chloridum,*

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[1] *United States Dispensatory.*

[2] *Inv. of Ver.* viii. 252.

bichloridum, hydrochloras, murias vel *oxymurias*), *corrosive sublimate* (*sublimatus corrosivus*), *corrosive muriate of mercury* (*hydrargyri murias corrosivus*), and *acidum chloro-hydrargyricum*).

PREPARATION.—There are several methods of obtaining it. Of these two only will require notice.

1. By subliming a mixture of persulphate of mercury and common salt.

The *London College* orders of Mercury, lbij.; Sulphuric Acid, lbiij.; Chloride of Sodium, lbjss. Boil down the Mercury with the Sulphuric Acid in a proper vessel, until the Bipersulphate of Mercury remains dry; rub this when it is cold with the Chloride of Sodium in an earthen mortar; then sublime with a heat gradually raised.

The *Edinburgh College* directs of Mercury, ℥iv.; Sulphuric Acid (commercial) f℥ij. and fʒiij.; Pure Nitric Acid, f℥ss.; Muriate of Soda, ℥iij. Mix the acids; add the mercury; dissolve it with the aid of a moderate heat; then raise the heat so as to obtain a dry salt. Triturate this thoroughly with the muriate of soda; and sublime in a proper apparatus.

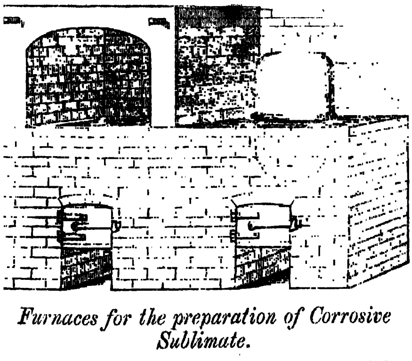
The *Dublin College* gives a separate formula for the preparation of the bipersulphate of mercury (*Hydrargyri Persulphas*, D). It is as follows:—

Take of purified Mercury, Sulphuric Acid, of each, *six parts*. Nitric Acid, *one part*. Let them be exposed to heat in a glass vessel, and let the fire be increased until the thoroughly dried residue shall have become white. From this salt corrosive sublimate is directed to be thus procured.

Take of Persulphate of Mercury, *five parts*; Dried Muriate of Soda, *two parts*. Let them be well rubbed together in an earthenware mortar, that a most subtile powder may be formed: then, with a heat gradually raised, let the Corrosive Muriate of Mercury be sublimed into a proper receiver.

Sulphate of mercury is usually prepared by submitting the sulphuric acid and mercury to heat in an iron pot, set in brickwork, over a proper fire, and under a hood or chimney to carry off the vapour of sulphurous acid (fig. 142 *a*), (see *ante*, p. 848).

FIG. 142.



Furnaces for the preparation of Corrosive Sublimate.

a. Furnace for the preparation of the persulphate of mercury. When the operation is going on, an iron plate is suspended in front of the hood, to prevent the escape of vapour.

b. Furnace for the sublimation of the perchloride.

The mixture of sulphate and common salt is subjected to sublimation in an earthen alembic placed in sand contained in an iron pot; or in an iron pot lined with clay, and covered by an inverted earthen pan (as in fig. 142 *b*). The same pot, with a different head, may be used in the preparation of calomel.

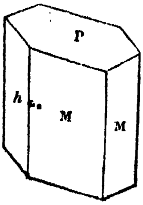
The nature of the changes which occur in the manufacture of persulphate of mercury have been already explained (see *ante*, pp. 846 and 848). When this salt is sublimed with chloride of sodium, double decomposition takes place, and we obtain perchloride of mercury and sulphate of soda, $HgO,SO^3 + NaCl = HgCl + NaO,SO^3$.

2. Perchloride of mercury may also be procured by the direct union of its constituents, chlorine and mercury. Dr. A. T. Thomson[1] has taken out a patent for this process.

Chemical Gazette, vol. i. p. 223, 1843.

PROPERTIES.—As usually met with in commerce, perchloride of mercury is a semi-transparent crystalline mass, in which perfect crystals are rarely found. Occasionally, however, they are obtained either by slow sublimation, or from a solution of the salt. Their form is the right rhombic prism. Their specific gravity is about 5·2 (5·14 to 5·42, Liebig). The taste of this salt is acrid, coppery, and persistent. When heated it fuses, boils, and volatilizes: the vapour is very acrid. It is soluble in about three times its weight of boiling, and in about eighteen or twenty times its weight of cold water: the acids (especially hydrochloric) and the alkaline chlorides increase its solubility. It is soluble in seven parts of cold or three and a half parts of boiling alcohol. Ether dissolves it more readily than alcohol, and will even separate it from its watery solution; and hence is sometimes employed to remove it from organic mixtures.

FIG. 143.



Crystal of Perchloride of Mercury.

An aqueous solution of perchloride of mercury readily undergoes decomposition, especially when exposed to solar light; calomel is precipitated, and hydrochloric acid set free. This change is facilitated by the presence of organic substances,—as gum, extractive, or oil; whereas it is checked by the presence of alkaline chlorides.

Albumen forms a white precipitate with an aqueous solution of perchloride of mercury. This precipitate is slightly soluble in water, and consists, according to Lassaigne,[1] of albumen, 93·45, and perchloride of mercury, 6·55. But, according to the experiments[2] of Rose, Geoghegan, Mulder, Marchand, and Elsner, it consists of from 10·278 to 11·192 of oxide of mercury, and from 89·722 to 88·808 of albumen. Fibrin forms a similar white compound with corrosive sublimate. When albuminous and fibrinous textures are immersed in a solution of this salt, combination takes place, the tissue contracts, increases in density, becomes whiter, and does not putrefy. Hence it is employed by the anatomist for hardening and preserving certain parts of the body—as the brain.

A solution of perchloride of mercury possesses some of the characters of an acid. Thus its solution reddens litmus, and it unites with the chlor-bases (as chloride of sodium), forming the double salts called *hydrargyro-chlorides*. Litmus which has been reddened by a solution of perchloride of mercury has its blue colour restored by chloride of sodium.

Characteristics.—Perchloride of mercury is recognised by the following characters:—

a. Heated in a tube by a spirit lamp, with caustic, or the carbonated fixed alkalies, an alkaline chloride is formed, oxygen, and, if a carbonate be used, carbonic acid gases are evolved, and metallic mercury is sublimed and condensed in the form of globules on the sides of the tube.

β. Lime-water causes a lemon-yellow precipitate *(hydrated red oxide of mercury)*. The supernatant liquid, acidified with nitric acid, yields with nitrate of silver a white precipitate (AgCl) insoluble in excess of nitric acid. If the perchloride be in excess, the precipitate is brick-red *(oxichloride of mercury,* HgCl,3HgO).

γ. Caustic ammonia, added to a solution of the perchloride, causes a white precipitate *(chloro-amidide of mercury,* $HgCl,HgAd{=}Hg^2,Cl,NH^2$).

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[1] *Journ. de Chim. Méd.* iii. 2e sér. 161.

[2] Sobernheim, *Physiologie der Arzneiwirkungen*, p. 67, 2te Aufl. 1843.

δ. The *alkaline mono-carbonates* throw down a brick-red precipitate ($HgCl,3HgO$); the *alkaline bicarbonates* cause opalescence but no immediate precipitate; in a few minutes, however, a dark reddish precipitate ($HgCl,3HgO$) is formed.

ε. *Iodide of potassium* occasions a scarlet precipitate (HgI)) soluble in excess, either of iodide of potassium, or of perchloride of mercury; the precipitate frequently appears at first of a yellow colour, though it quickly becomes scarlet.

ζ. *Protochloride of tin* added in excess to perchloride of mercury, causes first a white precipitate *(calomel)*, and afterwards a greyish powder, composed of reguline mercury, which falls down in a finely divided state. $HgCl+SnCl=Hg+SnCl^2$.

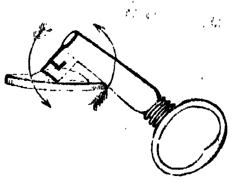
η. *Hydrosulphuric acid* in excess passed through a solution of perchloride of mercury, occasions a black precipitate (HgS). If the perchloride be in excess, a white precipitate (*chloro-sulphuret of mercury*, $2HgS,HgCl$) is obtained.

ϑ. *Ferrocyanide of potassium* causes a white precipitate (*ferrocyanide of mercury*).

ι. *Albumen* causes a white precipitate when added to a solution of corrosive sublimate.

κ. *Galvanism.*—Drop the suspected solution on a piece of gold (as a sovereign), and apply a key, so that it may touch, simultaneously, the gold and the solution; an electric current is immediately produced, the perchloride is decomposed, the mercury attaches itself to the negative electrode (or pole), namely, the gold, while the chlorine unites with the iron of the positive electrode (or pole) to form chloride of iron. The relative position of the gold, the key, and the solution, will be evident from the fig. 144, and the arrows point out the direction of the electric current. The silver stain left on the gold is readily removed by heat.

FIG. 144.



COMPOSITION.—The composition of this salt is as follows:—

	At.	*Eq. Wt.*	*Per Ct.*	*Turner.*
Mercury	1	100	73·8	73·53
Chlorine	1	35·5	26·2	26·47
Perchl. of Mercury	1	135 5	100·0	100·00

	Vols.	*Sp. Gr.*
Vapour of Mercury	1	6·97
Chlorine Gas	1	2·47
Vapour of Corrosive Sublimate	1	9·44

PURITY.—Pure perchloride should be white, dry, totally vapourized by heat, and completely soluble in water, alcohol, or ether.

It liquifies by heat, and sublimes. It is totally soluble in water and sulphuric ether. Whatever is thrown from water, either by solution of potash or lime-water, is of a reddish colour: or, if a sufficient quantity of water be added, it is yellow. This yellow substance by heat emits oxygen, and runs into globules of mercury.—*Ph. Lond.*

It sublimes entirely by heat; and its powder is entirely and easily soluble in sulphuric ether.—*Ph. Ed.*

PHYSIOLOGICAL EFFECTS. *a. On Vegetables.*—The effects of solutions of perchloride of mercury on plants have been examined by Seguin, and subsequently by Marcet and Macaire;[1] and from their experiments it appears, that when growing plants are immersed in a solution of this salt, part of the poison is absorbed, a change of colour takes place in the leaves and stems, and death is produced. It is equally poisonous to cryptogamic plants. Hence vegetable tissues soaked in a solution of it are no longer adapted for the development of the *Merulius lachrymans*, and of other fungi known under the name of the *dry rot*. This, in fact, is the principle adopted by Mr. Kyan[2] for the preservation of timber, and which is now practised by the *Anti Dry Rot Company*.[3]

β. On Animals generally.—The effects of corrosive sublimate on animals have been examined by Ettmuller, Wepfer, Sprœgel, Sir Benjamin Brodie,[1] Campbell, Lavort, Smith, Gaspard, Orfila,[2] Schubarth, and Bostock. An abstract of these will be found in the works of Wibmer,[3] and Christison.[4] Dogs, cats, horses, rabbits, and frogs, are the animals on which the experiments have been tried, and on which sublimate has been found to exercise a poisonous operation, and the same kind of effect is presumed, from analogy, to be produced on all other animals. The results of these experiments have been so briefly yet clearly stated by Dr. Christison, that I cannot do better than quote his words:—"Corrosive sublimate causes, when swallowed, corrosion of the stomach; and in whatever way it obtains entrance into the body, irritation of that organ and of the rectum, inflammation of the lungs, depressed action, and perhaps also inflammation of the heart, oppression of the functions of the brain, and inflammation of the salivary glands." I may add, that mercurial fœtor and salivation have been observed in horses, dogs, and rabbits.

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[1] De Candolle, *Phys. Vég.* 1332.

[2] *Lond. Med. Gaz.* xvi. 630. *Vide* also Dr. Dickson's *Lecture on Dry Rot*, Lond. 1837.

[3] See Keraudren, *Des Propriétés du Sublimé Corrosif pour la conservation du bois, et des effets de cette préparation sur la santé des marins*, in the *Mém. Royale Acad. de Méd.* t. v. p. 41, Paris

γ. *On Man.*—αα. *In small or therapeutic doses*, as from one-eighth to one-fourth of a grain, it frequently exerts a beneficial effect on diseases (syphilitic eruptions, for example), without producing any obvious alteration in the actions of the different organs. Occasionally, especially when the stomach and bowels are in an irritable condition, it gives rise to a sensation of warmth in the epigastrium, and causes nausea, griping, and purging. In such cases it is best to diminish the dose, and conjoin opium. By repetition, we frequently observe that the pulse becomes somewhat excited, and if the skin be kept warm, perspiration is oftentimes brought on; at other times the quantity of urine is increased. Continued use of it causes salivation; but it is said (and I am disposed to coincide in this statement) that corrosive sublimate has less tendency to occasion this effect than other preparations of mercury. Maximilian Locher,[5] who, from the year 1754 to 1762, cured 4,880 patients affected with the venereal disease, at St. Mark's Hospital, Vienna, by the exhibition of this remedy, says that no person died, or experienced the least painful or dangerous symptoms, in consequence of its use. He was, however, exceedingly cautious and careful in its employment, and always stopped its administration on the first appearance of salivation. Van Swieten says, "I am convinced, from repeated experience, that the menstrual evacuation is not disturbed by the use of this remedy."

ββ. *Chronic poisoning.—In somewhat larger doses, or by the long-continued use of the before-mentioned small doses*, gastro-enteritis, and all the usual constitutional effects of mercury, are brought on. Thus heat and griping pain in the alimentary canal (particularly in the stomach and rectum), loss of appetite, nausea, vomiting, purging, and disordered digestion, are the gastro-enteritic symptoms. The pulmonary organs, also, not unfrequently become affected; the patient complains of dry cough, pain in the chest, disordered respiration, and bloody expectoration. Coupling these symptoms

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1846. I have seen wood which had been prepared by Kyan's process, and which became black on the application of hydrosulphuret of ammonia (shewing the presence of mercury), covered with cottony fungi which grew from it. Sir John Barrow, in his *Life of Lord Anson*, says, wood thus prepared is attacked by the Teredo.

[1] *Phil. Trans.* for 1812.

[2] *Toxicol. Gén.*

[3] *Wirk. d. Arzn. u. Gifte.*

[4] *Treat. on Poisons.*

[5] Van Swieten's *Commentaries upon Boerhaave's Aphorisms*, xvii. 294.

with the effects said to be produced on the lungs of animals by the use of corrosive sublimate, we have an important caution not to administer it to patients affected with pulmonary disorders,—a caution, indeed, which Van Swieten gives; "for those," says he, "who have a husky, dry breast, are troubled with a cough, whose nervous system is excessively irritable, and are subject to a hemorrhage, bear not this remedy without detriment."

γγ. Acute poisoning.—In *very large doses* corrosive sublimate acts as a caustic poison, in virtue of its affinity for albumen, fibrin, and other constituents of the tissues. I shall follow Dr. Christison, and admit two varieties of poisoning by it, in one of which "the sole or leading symptoms are those of violent irritation of the alimentary canal. In another variety the symptoms are at first the same as in the former, but subsequently become conjoined with salivation and inflammation of the mouth, or some of the other disorders incident to mercurial erethysm, as it is called."

First variety: Gastro-enteritis.—In this variety the symptoms are analogous to those of other corrosive poisons: namely, violent burning pain in the mouth, throat, œsophagus, and stomach; difficulty of deglutition; sense of suffocation; nausea; violent vomiting, (increased by every thing taken into the stomach) of mucous, bilious, or sanguineous matters. The pain soon extends from the stomach over the whole abdomen, which becomes acutely sensible to the slightest impression; violent purging, often of blood; inexpressible anxiety; flushed countenance; restlessness; pulse quick, small, and contracted; cold sweats; burning thirsts; short and laborious respiration; urine frequently suppressed; and, lastly, various indications of a disordered condition of the nervous system, such as tendency to stupor, or even actual coma; convulsive movements of the muscle of the face and extremities: sometimes diminished sensibility of one of the limbs, or of the whole body; or even paraplegia. Occasionally death appears to result from the powerful effect produced on the nervous system, or from exhaustion, or from mortification of the bowels.

Dr. Christison points out the following characters as serving to distinguish poisoning by perchloride of mercury from that by arsenious acid:—

1. The symptoms begin much sooner.
2. The taste is much more unequivocal and strong.
3. The acridity and irritation in the gullet is much greater.
4. The countenance is flushed, and even swollen; whereas, in poisoning by arsenic, it is usually contracted and ghastly.
5. Blood is more frequently discharged by vomiting and purging.
6. Irritation of the urinary passages is more frequent.
7. Nervous affections are more apt to come on during the first inflammatory stage.
8. The effects are more curable than those of arsenic.
9. Deviations in the symptoms are more rare.

To these I may add, that the whitened condition of the epithelium of the mouth distinguishes corrosive sublimate poisoning from poisoning by arsenious acid.

Second variety: Gastro-enteritis, accompanied with or followed by mercurial erethysm.—I here use the term erethysm in the sense in which it is employed by Dr. Christison,—namely, to indicate all the secondary effects of mercury. In this variety, the symptoms first observed are those mentioned for the last variety, but they are followed sooner or later by those of inflammation of the salivary glands, and of the mouth and its neighbouring parts; profuse salivation, ulceration of the mouth, great fœtor of the breath, and other symptoms of this kind, already described.

Corrosive Sublimate eater.—Pouqueville[1] mentions as a common report, that in 1800 there lived at Constantinople a man called "Suleyman yeyen," or "Suleyman the eater of corrosive sublimate." He was 100 years old, and had taken sublimate for 30 years. In 1797 his daily dose exceeded a drachm! Thornton[2], Hobhouse[3], and Byron[4] refer to

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[1] *Voyage en Morée à Constantinople*, vol. ii. p. 126, Paris, 1805.
[2] *Present State of Turkey*, p. 295, Lond. 1807.
[3] *Journey through Albania*, &c. p. 945, 1813.
[4] *Works*, p. 765, 1837, 8vo. edition.

Pouqueville's statement, but no writer that I have met with professes to have seen this extraordinary poison eater. The story is, doubtless, entirely fabulous, or, if founded on any fact, has been greatly exaggerated. Although use may lessen the effect of agents whose active force is dynamical (see *ante*, p. 88), there is no evidence that by habit the affinity of the metallic salts for the organic constituents of the body is lessened. I have no hesitation, therefore, in refusing credence to Pouqueville's story.

USES.—*Internally*, it has been employed as a sialogogue, alterative, and diaphoretic.

The celebrated Baron Van Swieten[1] may be regarded as the principal introducer of corrosive sublimate into practice as a remedy for *venereal diseases*.[2] He seems to have been led to its employment from a suspicion that salivation was not requisite for curing this class of diseases; and hence he was desirous of obtaining some mercurial "that could be diluted at will, and so tried in a very small dose." Now corrosive sublimate possessed these properties, and hence he commenced his experiments with it, and meeting with great success, recommended it to Maximilian Locher, whose results I have already stated.[3] The balance of evidence is decidedly favourable to the employment of this medicine as an internal remedy for venereal diseases. By its partizans it has been asserted to be a safe and efficacious mercurial, to remove venereal symptoms in a very short space of time, and without causing salivation, merely by exciting diaphoresis. Its opponents[4] state, on the other hand, that other mercurials are quite as effectual and speedy; that the cure by corrosive sublimate is not permanent; and lastly, that its corrosive and irritant properties render its employment objectionable. One of the latest advocates for its use is Dzondi,[5] of Halle, who states that the best mode of using it is in the form of pills made with crumb of bread; and he gives the following formula for their preparation: — ℞ Hydr. Sublim. Corros. gr. xij., solve in Aq. Distill. q. s., adde Micæ Panis Albi, Sacchari Albi, aa. q. s. ut ft. pilulæ numero ccxl. Of these pills (each of which contains one-twentieth of a grain of corrosive sublimate), four are to be administered daily, and increased until thirty (containing one grain and a half) are taken at a dose. The best time of exhibiting them is after dinner. In irritable subjects and painful affections, a few drops of the tincture of opium may be taken with each dose. During the time the patient is under their influence, he should adopt a sudorific regimen (as is also recommended by Van Swieten), and take decoction of sarsaparilla.

In *acute diseases* few have ventured to employ perchloride of mercury: however, Schwartz gave it in hepatitis after the fever and pain had subsided, Sauter employed it in an epidemic scarlet fever, and Berends[6] administered it in asthenic malignant fevers. I have already noticed (p. 826) Mr. Lempriere's proposal to use it in fever as a sialogogue.

In various *chronic diseases* it has been given as an *alterative* and *diaphoretic* with occasional success. Thus in rheumatism, diseases of the bones, periodical pains, skin diseases, scrofulous affections, disorders of the nervous system, &c. In such it should be associated with diaphoretics (as antimony, sarsaparilla, &c.), warm clothing, &c. Not unfrequently opiates should be combined with it.

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[1] *Op. cit.*

[2] See also several papers on the use of perchloride in syphilis, in the *Medical Observations and Inquiries*, vols. i. and ii.

[3] For further historical details respecting its use, *vide* Pearson's *Observations on the Effects of various Articles of the Mat. Med.* p. 99 et. seq.

[4] *Vide* Pearson, *op. cit.*

[5] *Neue zuverläss. Heilart. d. Lusts. in allen ihren Formen*, &c. 1826, in Richter, *Ausf. Arzn.* Bd. v. S. 596.

[6] Richter, *Ausfür. Arzneim.* v. 581.

Corrosive sublimate is a valuable *sorbefacient* in old dropsical complaints, as those arising from diseased heart, liver, or lungs. From f℥ss. to f℥j. of the liquor hydrargyri bichloridi may be taken every six hours for many days or even weeks without affecting the mouth. Under its use I have repeatedly seen dropsical symptoms disappear.

As an *external* remedy, it has been employed as a *caustic* in substance (either alone or combined with arsenic) to cancerous ulcers, to parts bitten by rabid animals, to chancres, &c.: used in this way, however, it is mostly objectionable. In onychia maligna it is used with great advantage, mixed with an equal weight of sulphate of zinc, and sprinkled thickly upon the surface of the ulcer, which is then to be covered with a pledget of lint saturated with tincture of myrrh.[1] A *solution* has been employed for various purposes: thus by Baumé, as already mentioned (see *ante*, p. 823), for pediluvia, to produce salivation; as a lotion in chronic skin disease (as lepra, psoriasis, scabies, rosacea, &c.); as a wash to ulcers, particularly those of a venereal nature; as an injection in discharges from the urinary organs; as a collyrium in chronic diseases of the eye, especially those of a venereal nature; and as a gargle in ulcers of the tonsils. In obstinate gleet, where the constitution is not very irritable, an injection of a solution of corrosive sublimate frequently proves most effective. A solution is sometimes used as a preventive for the venereal disease.

I am informed that a most effective remedy for the contagious porrigo which spreads amongst children in schools, is an ointment composed of from gr. ss. to gr. ij. of corrosive sublimate to an ounce of lard.

Administration.—It may be used internally in substance or solution. The dose of it in substance is from one-sixteenth to one-eighth of a grain. Some advise it to be given to the extent of one-fourth of a grain, but in this dose it is very apt to gripe and purge. Dzondi's formula, already given, may be employed when we wish to administer it in substance.

In solution, it may be exhibited dissolved in water (see *liquor hydrargyri bichloridi*) alcohol, or ether.

For *external use*, a watery solution may be employed, containing from half a grain to two or three grains, dissolved in one ounce of water.

As an injection in gonorrhœa, from gr. $\frac{1}{8}$ to $\frac{1}{4}$ may be dissolved in an ounce of water.

Antidotes.—Several substances which decompose corrosive sublimate have been employed as antidotes. The most important of these are albuminous substances, the hydrated sulphuret of iron, and a mixture of iron filings and zinc.

When corrosive sublimate is mixed with *albumen*, a compound is formed whose chemical action on the tissues is slight as compared with that of perchloride of mercury. Hence the whites and yolks of eggs, milk, and a mixture of wheat-flour, oatmeal (or barley meal), and water, are used as antidotes.

Baron Thénard, the celebrated chemist, inadvertently swallowed a concentrated solution of corrosive sublimate, but by the immediate use of whites of eggs suffered no material harm. Peschier states that one egg is required for every four grains of the poison.

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[1] *United States Dispensatory.*

Albumen retards, but does not prevent, the absorption of the poison, and consequently does not preclude the production of the constitutional effects of corrosive sublimate.

The use of *hydrated sulphuret of iron* as an antidote for corrosive sublimate has been already noticed (see *ante*, p. 773).

A mixture of two parts of finely-divided *iron* (iron filings) and one of *zinc* has been recommended by Bourchardat, with the view of reducing corrosive sublimate to the metallic state.

Meconic acid and the *soluble meconates*, though by some supposed to be antidotes, have been shown by Mr. Allchin[1] not to be so in reality. That *opium* is a valuable agent in poisoning by this mercurial salt cannot be doubted; but its efficacy, though perhaps in part chemical, is chiefly dynamical. Its resinous and colouring matter, as well as, perhaps, to a certain extent, its meconic acid, forms with corrosive sublimate difficultly-soluble compounds. But its narcotic influence, by deadening the sensibility of living parts to the action of irritants, is the chief source of the utility of opium in poisoning by corrosive sublimate.

LIQUOR HYDRARGYRI BICHLORIDI, L.; *Solution of Bichloride of Mercury.* (Take of Bichloride of Mercury; Hydrochlorate of Ammonia, each, grs. x.; Distilled Water, Oj. Dissolve the bichloride of mercury and hydrochlorate of ammonia together in water.)—Hydrochlorate of ammonia is used to increase the solvent power of the water. Each fluidounce contains half a grain of corrosive sublimate. The dose of this solution is from half a fluidrachm to two or three fluidrachms, taken in some bland liquid, as linseed tea.

170. HYDRARGYRI AMIDO-CHLORIDUM.—AMIDO-CHLORIDE OF MERCURY.

Formula $Hg^2,Cl,N,H^2=HgCl,HgAd$. *Equivalent Weight* 251·5.

History.—This compound was discovered by Raymond Lully in the thirteenth century. Lemery pointed out two modes of procuring it, and hence it is sometimes termed *Lemery's white precipitate*, to distinguish it from precipitated calomel, also called on the continent "white precipitate." It has had various other appellations, as *cosmetic mercury* (*mercurius cosmeticus*), *white precipitated mercury* (*hydrargyrum præcipitatum album*); and according to the view taken of its composition, it has been called *muriate of ammonia and mercury*, *ammoniated submuriate of mercury* (*hydrargyri submurias ammoniatum*), *ammoniated mercury*, *ammoniacal oxychloruret of mercury*, and *ammonio-chloride of mercury* (*hydrargyri ammonio-chloridum.*) It is popularly called *white precipitate*, or *white oxide of mercury.*

Preparation.—All the British Colleges give formulæ for the preparation of this salt.

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[1] *Pharmaceutical Journal*, vol. viii. p. 264, 1848.

The *London College* orders of Bichloride of Mercury, ℥vj.; Distilled Water, Ovj.; Solution of Ammonia, f℥viij. Dissolve the Bichloride of Mercury, with the application of heat, in the water. To this, when it is cold, add the Solution of Ammonia, frequently stirring. Wash the powder thrown down until it is free from taste; lastly, dry it.

The *Edinburgh College* directs of Corrosive Sublimate, ℥vj.; Distilled Water, Ovj.; Aqua Ammoniæ, f℥viij. Dissolve the Corrosive Sublimate with the aid of heat in the Distilled Water; and when the solution is cold add the Aqua Ammoniæ; stir the whole well; collect the powder on a calico filter, and wash it thoroughly with cold water.

The *Dublin College* gives the following directions for its preparation:—Add to the liquor poured off from precipitated Calomel as much water of Caustic Ammonia as may be sufficient completely to throw down the metallic salt; which is to be washed with cold water and dried on bibulous paper.

By the addition of ammonia to a solution of perchloride of mercury, a white precipitate of the amido-chloride of mercury is formed, while there remains in solution half the chlorine of the perchloride combined with hydrogen and ammonia, as sal ammoniac. $2HgCl + 2NH^3 = HgCl,HgAd + NH^3,HCl$.

The process of the Dublin College is apparently, though not in reality, different from that of the London and Edinburgh Colleges for the preparation of white precipitate. The nitrate of mercury used for the preparing of precipitated calomel (see *ante*, p. 849) usually contains nitrate of the oxide, as well as nitrate of the suboxide. When, therefore, by the addition of a solution of common salt, calomel is precipitated, some corrosive sublimate is left in solution; and this yields amido-chloride of mercury on the addition of caustic ammonia.

PROPERTIES.—Amido-chloride of mercury occurs in commerce in masses or in powder. It is white, inodorous, has a taste at first earthy, afterwards metallic. It is decomposed and dissipated by heat, giving out ammonia, nitrogen, calomel, and water. It is insoluble in alcohol. By boiling in water we obtain a solution of hydrochlorate of ammonia, and a heavy yellow powder ($HgCl,2HgO,HgAd$), which is insoluble in water. It is soluble in sulphuric, nitric, and hydrochloric acids.

Characteristics.—When heated with caustic potash, it gives out ammonia, and forms a yellow powder (*white precipitated mercury and peroxide of mercury*, KANE). The solution contains chloride of potassium, and with nitrate of silver yields a white precipitate ($AgCl$), insoluble in nitric acid, but soluble in ammonia. Caustic ammonia does not alter white precipitate. By this it may, therefore, be distinguished from calomel, which yields a grey powder on the addition of ammonia. Protochloride of tin decomposes white precipitated mercury, and separates metallic mercury. To these characters must be added the effect of heat, water, and acids, as above-mentioned.

COMPOSITION.—Amido-chloride of mercury has the following composition:—

	At.	*Eq.Wt.*	*Per Ct.*	*Kane.*[1]	*Riegel.*
Mercury	2	200	79·522	78·60	78·85
Chlorine	1	35·5	14·115	13·85	13·86
Nitrogen	1	14	5·566	6·37	6·35
Hydrogen	2	2	0·795		
Amido-Chloride of Mercury	1	251·5	99·998	98·82	99·06
			HO	0·58	
				99·40	

Or	*At.*	*Eq.Wt.*	*Per Ct.*
Perchloride of Mercury	1	135·5	53·876
Amidide of Mercury	1	116	46·128
Amido-Chlor. of Mercury	1	251·5	99·9

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[1] *Trans. of the Royal Irish Academy*, vii. 423.

According to Hennel[1] and Mitscherlich[2] its composition is $2HgCl,NH^3,HCl$. Mr. Phillips[3] regards it as a compound of $HgCl,HgO,NH^3$.

PURITY.—This compound is largely adulterated with sulphate of lime. I have one sample containing one-third of its weight of this substance. Carbonate of lime and of lead are sometimes employed to mix with it. Pure white precipitate, thrown on a red-hot shovel, is dissipated without any residuum; whereas the above impurities remain. The carbonates are recognized by their effervescence on the addition of hydrochloric acid. Sulphate of lime may be detected by boiling the suspected substance in distilled water, and applying the tests for sulphates and calcareous salts, as before directed.

> Totally evaporated by heat. When digested with acetic acid, iodide of potassium throws down nothing either yellow or blue. The powder rubbed with lime-water does not become black. It is totally dissolved with hydrochloric acid without effervescence. When heated with solution of potash it becomes yellow, and emits ammonia.—*Ph. Lond.*

The iodide of potassium is employed to detect lead or starch in the acetic solution. If lime-water occasion a black precipitate, it indicates the presence of a protosalt of mercury.

PHYSIOLOGICAL EFFECTS.—Its action on the body is very imperfectly known, no recent experiments having been made with it. It is usually considered to be highly poisonous, and somewhat similar in its operation to perchloride of mercury. Palmarius and Naboth[4] have reported fatal cases of its use.[5]

USES.—It is employed as an external agent only; commonly in the form of an ointment. It is an efficacious application in various skin diseases—as porrigo, impetigo, herpes, and even scabies; also in ophthalmia tarsi. Among the lower classes it is commonly used to destroy pediculi.

ANTIDOTE.—See *corrosive sublimate*, p. 863.

UNGUENTUM HYDRARGYRI AMMONIO-CHLORIDI, L.; *Unguentum Præcipitati albi*, E.; *Unguentum Hydrargyri Submuriatis Ammoniati*, D.; *Ointment of White Precipitate*. (White Precipitate, ʒj.; Lard, ℥iss. Mix.)—Stimulant, alterative, and detergent. Used in various skin diseases as above mentioned.

171. HYDRARGYRI IODIDA.—IODIDES OF MERCURY.

Three compounds of mercury and iodine are known. They are as follows:

Subiodide of Mercury (*protiodide*)	Hg^2I
¾ Iodide (*sesquiodide*)	Hg^4I^3
Periodide (*biniodide*)	HgI

Of these the first and the third are used in medicine.

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[1] *Quarterly Journal of Science*, xviii. 297.

[2] *Ann. Chim.* xxxv. 428.

[3] *Translation of the London Pharmacopœia.*

[4] Wibmer, *Wirk. d. Arzn.* iii. 64.

[5] Vide also Gmelin, *App. Medicam.* ii. 166.

1. Hydrargyri Subiodidum.—Subiodide of Mercury.

Formula Hg^2I. *Equivalent Weight* 326.

HISTORY.—This compound is commonly called *protiodide of mercury* (*hydrargyri iodidum*), or simply *iodide of mercury* (*hydrargyri iodidum*). It may be distinguished also as *green subiodide of mercury* (*hydrargyri subiodidum viride*.)

PREPARATION.—There are several methods of preparing it.

The *London College* orders of Mercury, ℥j.; Iodine, ʒv.; Alcohol, *as much as may be sufficient*. Rub the Mercury and Iodine together, adding the alcohol gradually, until globules are no longer visible. Dry the powder immediately, with a gentle heat, without the access of light, and keep in a well-stoppered vessel.

In this process the mercury and iodine enter into combination. The alcohol facilitates the union by dissolving a portion of iodine and forming with the remainder a pasty mass. Some red or periodide is usually first formed, and is afterwards transformed into the green or subiodide by uniting with mercury.

This process succeeds well when small quantities of iodide are to be prepared; but it is scarcely applicable to the preparation of large quantities, owing to the great heat which is evolved, by which iodine is volatilized, and some red or periodide formed. Soubeiran[1] says that the mass sometimes inflames, and escapes from the mortar with a kind of explosion. To avoid these inconveniences small quantities only (seven or eight ounces, for example) should be prepared at one time, and the quantity of alcohol should be augmented.

Another mode of preparing it is by the addition of solution of iodide of potassium to a solution of the suboxide of mercury, acidified with a very small quantity of nitric acid, as long as a greenish precipitate is produced. There are, however, some difficulties in this mode of proceeding. A subnitrate of mercury is apt to be precipitated with the subiodide, and if, to avoid this, we use excess of nitric acid, this decomposes the iodide of potassium and sets iodine free, which combines with the subiodide to form the red or periodide. If the solution of protonitrate be added to that of the iodide of potassium, metallic mercury and red or periodide are apt to be formed: the latter is at first dissolved, but is afterwards deposited with the subiodide.

PROPERTIES.—It is a dingy green powder, whose sp. gr. is 7·75. It is insoluble in water, alcohol, or an aqueous solution of chloride of sodium; but is soluble in ether, and slightly so in an aqueous solution of iodide of potassium. When heated quickly, it fumes, and sublimes in red crystals, which become yellow by cooling. Solar light decomposes it, and changes its colour. Heated with potash, it yields iodide of potassium and reguline mercury.

When recently prepared it is yellowish, and when heat is cautiously applied it sublimes in red crystals, which afterwards become yellow, and then by access of light they blacken. It is not soluble in chloride of sodium.—*Ph. Lond.*

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[1] *Nouveau Traité de Pharmacie*, t. ii. p. 513, 2nde éd.

Composition.—It consists of

	Atoms.	Eq. Wt.	Per Cent.
Mercury	2	200	61·35
Iodine	1	126	38·65
Iodide of Mercury	1	326	100·00

Physiological Effects.—It is a powerful irritant poison. A scruple killed a rabbit within twenty-four hours, and a drachm destroyed a pointer dog in five days.[1]

In small but repeated doses, it appears to exercise a specific influence over the lymphatic and glandular system. Two grains taken daily caused salivation in two instances.[2]

Uses.—It has been used in syphilis and scrofula, especially when they occur in the same individual. Lugol[3] employed an ointment of it in those forms of external scrofulous disease which resemble syphilis. Ricord[4] gave it internally with good effect in *syphilis infantum.* Biett[5] has successfully employed it in syphilitic ulceration and venereal eruptions.

Administration.—The dose of it for adults is from one grain gradually increased to three or four. Ricord gave from one-sixth to one-half of a grain to children of six months old. Biett employed it internally, and also externally, in the form of ointment, to the extent of twelve or fourteen grains daily, by way of friction.

1. **PILULÆ HYDRARGYRI IODIDI**, L.; *Pills of Iodide of Mercury.* (Iodide of Mercury, ℨj.; Confection of Dog-rose, ℨiij.; Ginger, powdered, ℨj. M.)—Five grains of these pills contain one grain of iodide. The dose, therefore, will be from five grains to a scruple.

2. **UNGUENTUM HYDRARGYRI IODIDI**, L.; *Ointment of Iodide of Mercury.* (Iodide of Mercury, ℥j.; White Wax, ℥ij.; Lard, ℥vj. M.)—This is used as a dressing for scrofulous ulcers, or for syphilitic ulcers in scrofulous subjects. It is also employed in tubercular skin diseases,—as lupus, rosacea, and sycosis.[6]

2. Hydrargyri Periodidum.—Periodide of Mercury.

Formula HgI. *Equivalent Weight* 226.

History.—This compound is usually termed *biniodide of mercury* (*hydrargyri biniodidum*). It is also called the *deutiodide of mercury.*

Natural History.—It is found native in Mexico, in the form of reddish brown particles.

Preparation.—Both the London and Edinburgh Colleges give directions for the preparation of this compound.

The *London College* orders of Mercury, ℥j.; Iodine, ℨx.; Alcohol as much as may be sufficient; rub the mercury and iodine together, adding the alcohol gradually, until the globules are no longer visible. Dry the powder immediately, with a gentle heat, without the access of light, and keep in a well-stoppered vessel.

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[1] Cogswell, *Essay on Iodine and its Compounds*, p. 160.

[2] Biett, *Lancette Française*, Juin 1831.

[3] *Essays on the Effects of Iodine in Scrofulous Disorders*, by Dr. O'Shaughnessy, p. 170.

[4] *Lancette Française*, 1835, No. 65.

[5] O'Shaughnessy's *Trans. of Lugol's Essays*, p. 201.

[6] Rayer, *Treat. on Skin Diseases.*

The *Edinburgh College* directs of Mercury, ℥ij.; Iodine, ℥ijss.; Concentrated Solution of Muriate of Soda, *a Gallon*. Triturate the Mercury and Iodine together, adding occasionally a little rectified spirit till a uniform red powder be obtained. Reduce the product to fine powder, and dissolve it in the solution of muriate of soda with the aid of brisk ebullition. Filter, if necessary, through calico, keeping the funnel hot; wash and dry the crystals which form on cooling.

In these processes the iodine and mercury combine to form the per- or biniodide. The alcohol facilitates the combination by dissolving part of the iodine, and forming a pasty mass with the remainder.

The solution of common salt employed by the Edinburgh College serves to separate the per- or biniodide from any subiodide (which is insoluble in that liquid), as well as to obtain the biniodide in a crystalline form.

Considerable inconvenience is experienced in obtaining large quantities of the periodide by the above process, on account of the great heat evolved when mercury and iodine are rubbed together.

Per- or biniodide of mercury may be readily obtained by mixing solutions of perchloride of mercury and iodide of potassium. One equivalent or 135·5 grains of corrosive sublimate are required to decompose one equivalent or 165 parts of iodide of potassium. $HgCl+KI=HgI+KCl$.

In order to obtain a fine-coloured per- or biniodide, and to ensure the absence of perchloride of mercury in the product, a slight excess of iodide of potassium should be employed. This, indeed, holds a little biniodide of mercury in solution, but the quantity is inconsiderable. A large excess of iodide of potassium combines with the biniodide, and forms therewith a soluble double salt (HgI,KI). If the perchloride of mercury be slightly in excess, a pale-red precipitate (composed of biniodide of mercury with a little perchloride) is obtained. A great excess of perchloride of mercury keeps the periodide in solution.

PROPERTIES.—Periodide of mercury is a dimorphous substance; its colour and crystalline form varying with its temperature.

a. Red Periodide of Mercury.—At ordinary temperatures, and as usually met with, periodide of mercury is a scarlet red powder, whose sp. gr. is from 6·2 to 6·32. It is insoluble in water, but soluble in alcohol, some acids, alkalies, and solutions of iodide of potassium, chloride of sodium, and of many of the mercurial salts. When dissolved to saturation in a hot solution of either iodide of potassium or iodide of zinc, it is deposited on cooling in the form of square octohedrons. When heated, the red periodide becomes bright yellow, and then fuses, forming a deep ruby-red or amber-coloured liquid, which by cooling congeals into a yellow crystalline mass (*var.* β). This, by further cooling, or by mechanical disturbance, or by partial disintegration, suddenly assumes a scarlet colour: the change commencing in the latter case at the point ruptured.[1] If the heat be raised sufficiently, the fused periodide is volatilized, and sublimes in the form of yellow right rhombic prisms (*var.* β); but if the temperature be very slowly raised, and the sublimation be carefully conducted, red crystals, having the form of square octohedrons, are obtained.

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[1] Warington, *Memoirs of the Chemical Society*, vol. i. p. 85, 1843.

β. *Yellow Periodide of Mercury.*—This is obtained by heating the red periodide; by fusing and partially cooling the red periodide; by subliming the red periodide; and also by precipitation from a solution of a persalt of mercury by iodide of potassium: in the latter case the yellow crystalline grains soon dissolve, and at the same time crystals of the red periodide make their appearance. The citron yellow crystals of periodide belong to the right prismatic system: they are not permanent, but readily pass into the red state.

Characteristics.—Heated with carbonate of potash in a tube, it yields metallic mercury, which is volatilized: the residue is iodide of potassium, recognizable by the tests before described (see *antè*, p. 496). From the subiodide of mercury it is distinguished by its colour and its solubility in a solution of chloride of sodium. The effects of heat on it, and its solubility in iodide of potassium, are other characters which serve to recognise it.

COMPOSITION.—Its composition is as follows:—

	Atoms.	*Eq. Wt.*	*Per Cent.*		*Vols.*
Mercury	1	100	44·25	Vapour of Mercury	1
Iodine	1	126	55·75	Vapour of Iodine	1
Biniodide of Mercury	1	226	100·00	Vapour of Iodide of Mercury	1

PURITY.—The presence of persulphuret of mercury in it may be recognised by fusion with caustic potash in a glass tube, by which a mixture of sulphuret and iodide of potassium is obtained: the existence of sulphur may be proved by the evolution of hydrosulphuric acid on the addition of a mineral acid.

By heat, cautiously applied, it is sublimed in scales, which soon become yellow, and afterwards, when they are cold, red. It is partially soluble in boiling rectified spirit, which affords crystals as it cools. It is alternately dissolved and precipitated by iodide of potassium and bichloride of mercury. It is totally soluble in chloride of sodium.—*Ph. Lond.*

"Entirely vaporizable: soluble entirely in 40 parts of a concentrated solution of muriate of soda at 212°, and again deposited in fine red crystals on cooling."—*Ph. Ed.*

PHYSIOLOGICAL EFFECTS. α. *On Animals.*—A scruple killed a rabbit in twenty-four hours: the stomach was found preternaturally reddened. Ten grains, dissolved in a solution of iodide of potassium, and given to a dog, caused vomiting, pain, tenesmus, and depression: in four or five days the animal was well.[1] Maillet[2] has also made some experiments with it.

β. *On Man.*—It is a powerful irritant and caustic. It is nearly as powerful as the perchloride of mercury; indeed, Rayer[3] considers it more active than the latter. Applied to ulcers, in the form of ointment, I have known it cause excruciating pain. Left in contact with the skin for a while, it induces, says Rayer, a most intense erysipelatous inflammation. It requires to be administered internally with great caution. Like other mercurial compounds, its repeated use causes salivation.

USES.—It has been employed in the same cases (*i. e.* syphilis and scrofula) as the subiodide of mercury, than which it is much more energetic. Breschet[4] applied it, in the form of ointment, with great success in a case of obstinate ulceration (thought to have been carcinomatous) of the angle of the eye. In the form of a dilute and thin ointment (composed of periodide of mercury, gr. ij.; cerate, ℈ij.; and almond oil, ℈j.) it has been used in opacity of the cornea.[1] In obstinate ophthalmia tarsi, with thickening of the meibomian glands, it has also been successfully employed.

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[1] Cogswell, *Essay on Iodine*, p. 164.

[2] *Journ. de Chim. Méd.* iii. 543, 2de série.

[3] *Treatise on Skin Diseases*, by Dr. Willis, p. 79.

[4] O'Shaughnessy's *Transl. of Lugol's Essays*, p. 204.

ADMINISTRATION.—It should be given in doses of one-sixteenth of a grain, gradually increased to one-fourth of a grain. It may be exhibited in the form of pills, or dissolved in alcohol or ether.

1. UNGUENTUM HYDRARGYRI BINIODIDI, L.; *Ointment of Biniodide of Mercury.* (Biniodide of Mercury, ʒj.; White Wax, ʒij.; Lard, ℥vj. M.) Used in the before-mentioned cases. For ordinary purposes it will require to be considerably diluted.

2. LIQUOR HYDRARGYRI IODO-ARSENITIS; *Solution of the Iodo-Arsenite of Mercury; Liquor Hydriodatis Arsenici et Hydrargyri; Donovan's Solution.* This solution was introduced into medical use in November 1839, by Mr. Donovan,[2] who gave the following directions for its preparation:—

> "Triturate 6·08 grains of finely levigated metallic arsenic, 15·38 grains of mercury, and 50 grains of iodine, with one drachm measure of alcohol, until the mass has become dry, and from being deep brown has become pale red. Pour on eight ounces of distilled water, and after trituration for a few moments, transfer the whole to a flask; add half a drachm of hydriodic acid, prepared by the acidification of two grains of iodine, and boil for a few minutes. When the solution is cold, if there be any deficiency of the original eight ounces make it up exactly to that measure with distilled water. Finally, filter."

When the arsenicum, mercury, and iodine, are triturated together with the alcohol, the iodine combines with the metals. The quantity of iodine is about sufficient to convert the arsenicum into the teriodide, AsI^3, and the mercury into the periodide, HgI. We may therefore regard this solution as essentially consisting of these two iodides in solution or combination. Mr. Donovan considers that, by solution in water, these two become converted into hydriodates; but there is no evidence of this.

Each fluidrachm of this solution contains a quantity of teriodide of arsenic equivalent to one-eighth of a grain of arsenious acid; and of per- or iodide of mercury, equivalent to a quarter of a grain of the peroxide of mercury. In addition, it also contains a minute portion of hydriodic acid, which Mr. Donovan estimates as equal to three-quarters of a grain of iodine.

"The colour of the solution is yellow, with a pale tinge of green; its taste is slightly styptic. It cannot be properly conjoined with the tincture of opium, or with sulphate, muriate, or acetate of morphia; for all these produce immediate and copious precipitates in it. Hence, if opiates are to be used during the exhibition of this arsenico-mercurial liquor, they must be taken at different periods of the day. Tincture of ginger produces no bad effect. The following formula is proper:—℞ Liq. Hydriodatis Arsenici et Hydrargyri, ʒij.; Aquæ Distillatæ, ℥iiiss.; Syrupi Zingiberis, ℥ss. Misce. Divide in haustus quatuor. Sumatur unus mane nocteque." (Donovan.) Each of these draughts contains the equivalent of one-sixteenth of a grain of arsenious acid, and the equivalent of one-fourth of a grain of the peroxide of mercury.

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[1] Gräfe and Walther's *Journ. f. Chir.* Bd. 13.

[2] *Dublin Medical Journal*, vol. xvi. for November 1839; and *Pharmaceutical Journ.* vol. i. p. 425, 1842.

"The division into draughts is here necessary; first, to insure accuracy of the dose, so essential in the case of this active medicine; and, next, to prevent injury to the ingredients by the use of a metallic spoon as a measure, the general way in which, unfortunately, the dose of a medicine is determined." (Donovan.)

On repeating this process, Soubeiran[1] found that a portion of arsenic remained undissolved; he has, therefore, proposed the following simple substitute for Donovan's formula:—Teriodide of arsenic, one part; periodide (biniodide) of mercury, one part; water, 98 parts. To make f℥viij. on this principle, take teriodide of arsenic, gr. xxxv.; periodide (biniodide) of mercury, gr. xxxv.; boiling distilled water, ℥viij. Triturate until dissolved, and then filter the solution; and, if necessary, add water to make exactly ℥viij. of solution.

Soubeiran's solution is somewhat stronger than Donovan's. The following table shews the comparative quantities of the active ingredients in the two solutions, reduced to French grammes:—

	Donovan.	*Soubeiran.*
Arsenic	0·158 grammes.	0·165 grammes.
Mercury	0·400 "	0·445 "
Iodine	1·318 "	1·489 "

Soubeiran's solution contains exactly one-hundredth part of each of the iodides.

Both Donovan's and Soubeiran's solutions contain the teriodide of arsenic and periodide of mercury, and, therefore, combine the effects of both of these salts. It sometimes occasions ptyalism.

Donovan's solution has been most successfully employed in obstinate skin diseases, such as lupus, lepra, psoriasis, pityriasis, and impetigo. It has proved very effective in chronic cutaneous affections of the scalp, and in venereal eruptions, and in some uterine diseases.[2]

The dose of it is from ♏x. to ʒss. (see *supra*). When diluted with an equal proportion of water, it has been employed as a wash in the same cases in which it has been administered internally.

172. HYDRARGYRI NITRATES.—NITRATES OF MERCURY.

Six solid compounds of nitric acid and the oxides of mercury are known: three are nitrates of the suboxide, and three nitrates of the oxide.

Nitrates of the Suboxide of Mercury	Bibasic Nitrate of the Suboxide of Mercury	$2Hg^2O,NO^5,HO$
	Sesquibasic Nitrate of the Suboxide (crystallized)	$3Hg^2O,2NO^5,3HO$
	Neutral Nitrate of the Suboxide (crystallized)	$Hg^2O,NO^5,2HO$
Nitrates of the Oxide of Mercury	Sexbasic Nitrate of the Oxide of Mercury	$6HgO,NO^5$
	Tribasic Nitrate of the Oxide	$3HgO,NO^5,HO$
	Bibasic Nitrate of the Oxide (crystallized)	$2HgO,NO^5,2HO$

In addition, there are possibly other mercurial nitrates obtained in solution, but they have not hitherto been procured in the solid state.

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[1] *Journal de Pharmacie*, t. xxvii. p. 744, 1841.

[2] See *Dublin Medical Journal*, vols. xviii. xxi. and xxii.

Of these compounds, it will be necessary to notice two only—namely, the neutral nitrate of the suboxide, and the bibasic nitrate of the oxide.

1. Hydrargyri Protonitras.—Neutral Nitrate of the Suboxide of Mercury.

Formula Hg^2O,NO^5. *Equivalent Weight* 262.

NATURAL HISTORY.—Glocker[1] mentions, on the authority of John, a doubtful mineral which he calls *hydrargyronitrites*, composed of suboxide of mercury and nitric acid.

PREPARATION.—Neutral nitrate of the suboxide of mercury is obtained by digesting excess of mercury in cold dilute nitric acid until *short prismatic crystals* ($Hg^2O,NO^5,2HO$) are formed.

If these be left in the solution they are gradually dissolved and replaced by large transparent prisms of the sesquibasic nitrate of the suboxide ($3Hg^2O,2NO^5,3HO$).

PROPERTIES.—The neutral nitrate is soluble without decomposition in a small quantity of water; but in much water its crystals are decomposed into a yellow powder (*bibasic nitrate of suboxide of mercury*, $2Hg^2O,NO^5,HO$), and an acid liquor (*solutio hydrargyri frigide parata*) which contains a soluble supernitrate.

PURITY.—Neutral nitrate of the suboxide of mercury is distinguished from other nitrates in the following way:—If it be rubbed with excess of chloride of sodium, and water subsequently added, the whole of the mercury is thrown down in the form of a white precipitate of calomel, and no perchloride of mercury (corrosive sublimate) can be detected in the filtered liquid. But if any oxide (peroxide) had been present along with the suboxide, some corrosive sublimate would be found in the filtered liquid; and if any basic nitrate of the suboxide had been present a greenish powder (a mixture of calomel and suboxide of mercury) would be formed.

PHYSIOLOGICAL EFFECTS.—The effects of protonitrate may be considered as intermediate between those of calomel and corrosive sublimate. After its ingestion it probably becomes converted into calomel by the action of the alkaline chlorides contained in the alimentary canal. According to Mialhe,[2] if atmospheric oxygen and an excess of alkaline chloride be present, a portion of corrosive sublimate is formed.

USES.—Protonitrate of mercury is rarely used as a medicine. The facility with which it undergoes decomposition by contact with various organic substances is an objection to its internal employment. Its principal medicinal use is, in the form of solution, as a cathæretic or mild caustic in venereal ulcerations and growths. It has also been used in porrigo and in diseases attended with pediculi (Rayer). Biett[3] employed an ointment, composed of 2 parts of protonitrate and 50 parts of lard, in lepra and psoriasis. Dupuytren's *antiherpetic pommade* consisted of two parts of the protonitrate, eight parts of lard, and one part of rose oil. As an internal remedy, the protonitrate may be administered in doses of from $\frac{1}{16}$th to $\frac{1}{8}$th of a grain, in the form of pill made with extract of liquorice.

In pharmacy the protonitrate serves for the preparation of *hydrargyri nitrico-oxydum* (see *ante*, p. 840), *calomelas præcipitatum* (see *ante*, p. 849), sometimes for the production of *hydrargyri subiodidum* (see *ante*, p. 867), and also for the preparation of *hydrargyri acetas* (see p. 878). In chemistry its solution is used as a test.

LIQUOR HYDRARGYRI PROTONITRATIS; *Liquor Hydrargyri Nitrici*, Ph. Boruss. 1847; *Liquor Hydrargyri Nitrici Oxydulati*.—Prepared by dissolving one ounce of the crystals of protonitrate of mercury in eight ounces of distilled water to which three and a half scruples of nitric acid have been added; filter the solution, and if necessary add water, so that the sp. gr. of the liquor may be 1·100. Preserve it carefully in a stoppered vessel. The dose of this solution is three drops.

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[1] *Genera et Species Mineralium secundum Ordines Naturales Digestorum Synopsis*, 1847, p. 302.

[2] *Traité de l'Art de Formuler*, p. 72, 1845.

[3] Bourchardat, *Nouveau Formulaire Magistral*, p. 321, 1845.

2. Hydrargyri Dipernitras.—Bibasic Nitrate of the Oxide of Mercury.

Formula $2HgO,NO^5$. *Equivalent Weight* 270.

PREPARATION.—By boiling mercury in strong nitric acid, until the liquid, when diluted with water, ceases to yield a white precipitate (calomel) on the addition of a solution of common salt, we obtain a solution of the nitrate of the oxide of mercury (*solutio mercurii calide parata*). By concentration, it acquires the density of 3·47. In this state it has an acrid metallic taste, and colours the skin, when exposed to light, purplish-red. The solution probably contains *neutral nitrate of the oxide of mercury*, HgO,NO^5. But by evaporation acid fumes escape, and there are formed crystals of the bibasic nitrate, $2HgO,NO^5,2HO$.

PROPERTIES.—If the crystallized bibasic nitrate be washed with cold water as long as the liquid runs off sour, a heavy yellow powder is obtained, which is the *tribasic nitrate of the oxide of mercury*, $3HgO,NO^5,HO$: this, when boiled in water, yields a brick-red powder, which is the *sexbasic nitrate of the oxide of mercury*, $6HgO,NO^5$.

PURITY.—The presence of nitrate of the suboxide of mercury in a solution of nitrate of the oxide of mercury, is known by the production of a white precipitate (calomel) on the addition of a solution of common salt (see *ante*, p. 873).

PHYSIOLOGICAL EFFECTS.—This nitrate is more acrid and caustic than the protonitrate. Its effects are analogous to those of corrosive sublimate. Indeed, it becomes converted, in the alimentary canal, into the latter salt by the action of the alkaline chlorides it there meets with.

USES.—Internally, it is now never employed. It was formerly given in doses of $\frac{1}{16}$th of a grain. Externally, it is used in two forms,—as an acid solution, and as an ointment.

1. LIQUOR HYDRARGYRI SUPERNITRATIS; *Solution of Supernitrate of Mercury; Nitras Hydrargyricus Acido Nitrico Solutus; Liquid Acid Deutonitrate of Mercury; Acid Nitrate of Mercury.* (Take of Mercury, four parts by weight; Nitric Acid [sp. gr. 1·321], eight parts by weight. Dissolve the mercury in the nitric acid, and evaporate the solution to nine parts.)—This solution is dense and very caustic. It contains 71 per cent. of pernitrate of mercury, and an excess of nitric acid. It is frequently employed in the Parisian hospitals as a caustic. Biett frequently employed it with success in lupus. It should be applied to the extent of a crown-piece, by means of a brush, to the ulcers, tubercles, and scars which remain soft or purple, and seem on the point of breaking: lint moistened with the solution is then to be applied to the cauterized surface. The parts immediately become white, a kind of erysipelatous inflammation is set up in the surrounding parts, and in a few days a yellow scab gradually falls off.

This solution is also used for the cauterization of the ulcerated cervix uteri. "When the inflammation is intense, the ulceration large, and the granulations redundant or unhealthy, it exercises a very prompt and beneficial influence, generally cleansing and modifying the sore in one application. In very slight ulcerations, however, I think it is too powerful a remedy, and that the solid nitrate of silver answers the purpose better."[1]

It has been used by Recamier[2] as a caustic in cancerous diseases. He thinks it acts specifically, and modifies the vital actions of the surrounding parts. The acute pain which its application causes is alleviated by a strong solution of opium. Godard[3] employed it in herpes exedens. It has likewise been used with success in a great variety of other cases,—as syphilitic and scrofulous ulcers, condyloma, obstinate lepra and psoriasis, porrigo favosa, &c. &c.

By the local use of this acid nitrate of mercury, the constitutional effects of mercury have been produced. Breschet has seen salivation induced by one application of it to the ulcerated neck of the uterus.[4] In such cases it probably passes into the system in the form of corrosive sublimate, into which salt it is converted by the alkaline chlorides contained in the secretions of the part to which it is applied. To prevent absorption, Mialhe recommends that the cauterized part should be washed immediately after the application of the caustic.

2. UNGUENTUM HYDRARGYRI NITRATIS; *Ointment of Nitrate of Mercury; Yellow* or *Citrine Ointment* (*Unguentum Citrinum*); *Mercurial Balsam* (*Balsamum Merceuriale*).—It is an imitation of the *golden eye-ointment*. All the British Colleges give directions for its preparation.

The *London College* orders of Mercury, ℥j.; Nitric Acid, f℥xi.; Lard, ℥vj.; Olive Oil, f℥iv. First dissolve the Mercury in the Acid; then mix the solution while hot with the Lard and Oil melted together.

The *Edinburgh College* directs of Pure Nitric Acid, sp. gr. 1·380 to 1·390, f℥ixss.; Mercury, ℥iv.; Axunge, ℥xv.; Olive Oil, f℥xxxviiiss. Dissolve the mercury in the acid with the aid of a gentle heat. Melt the axunge in the oil with the aid of a moderate heat in a vessel capable of holding six times the quantity; and while the mixture is hot, add the solution of mercury, also hot, and mix them thoroughly. If the mixture do not froth up, increase the heat a little till this takes place. Keep this ointment in earthenware vessels, or in glass-vessels, secluded from the light.[5]

The *Dublin College* orders of Purified Mercury, *by weight*, ℥j.; Nitric Acid, ℥xiss.; Olive Oil, Oj. [*wine measure*]; Prepared Hog's Lard, ℥iv. Dissolve the mercury in the acid; then, having melted the oil and lard together, mix them and make an ointment in the same manner as the ointment of nitric acid.

By the action of concentrated nitric acid on mercury, nitrate of the oxide of mercury is produced. $3Hg+4NO^5=3(HgO,NO^5)+NO^2$. The London, and especially the Edinburgh College, use excess of nitric acid. When the solution is mixed with the lard and olive oil, a portion of elaïdine[6] is produced, as well as a red viscid oil. Soubeiran[7] says that carbonic acid and binoxide of nitrogen gases are evolved, but Mr. Schacht[8] could not detect them. He obtained only the vapour of nitric acid, having the peculiar smell of the ointment.

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[1] *A Practical Treatise on Inflammation, Ulceration, and Induration of the Neck of the Uterus*, by J. H. Bennet, M.D. p. 147, 1845.

[2] *Rech. sur le Traitement du Cancer*, 1829.

[3] *De l'Emploi du Nitrate Acide de Mercury*: Thèse présentée et soutenue à la Faculté de Médecine de Paris, 1826. Also *Archives Générales de Médecine*, t. xi. pp. 203-207.

[4] Trousseau and Pidoux, quoted by Mialhe, in his *Traité de l'Art de Formuler*, p. 84, 1845.

[5] There is an error in the Edinburgh Pharmacopœia in the proportion of olive oil and in the density of nitric acid (see Christison's *Dispensatory*, 2d edit. p. 531). In the text I have corrected this error.—J. P.

[6] So called by Boudet (*Journ. de Chim. Méd.* viii. 641) from *ἐλαΐς, ἐλαΐδος, an olive tree.* Boudet ascribes the formation of the elaidine to the action of nitrous or hyponitrous acid.

[7] *Nouv. Traité de Pharmacie*, t. ii. p. 256.

[8] *Pharmaceutical Journal*, vol. iv. p. 451, 1845.

By keeping, this ointment is apt to change its colour, and become hard, pulverizable, and thereby unfit for use. The nitrate of the oxide of mercury undergoes deoxidation, and is ultimately reduced to metallic mercury. The grey colour which the ointment acquires by keeping is due to the dissemination of minute globules of metallic mercury through the mass. If old citrine ointment be digested in ether, the fatty matters are dissolved, and metallic mercury left behind. The cause of this change appears to be the use of an insufficient quantity of nitric acid and of too low a temperature. Mr. Duncan, of Edinburgh, first showed that "by dissolving the metal in an excess of acid with the aid of heat, using an additional quantity of acid for oxygenating all the fat, and applying a moderate heat at the time of mixing the fat and the metallic solution, so as to ensure complete action between them,—an ointment is obtained not inferior to the quack nostrum [*golden eye-ointment*] in original colour or durability."[1] The present formula of the Edinburgh College (as now corrected) is that of Mr. Duncan. MM. Henry and Guibourt[2] also direct a considerable excess of acid to be employed.

The following are several formulæ for its preparation:—

	United States Dispensatory.	*Paris Codex.*	*Henry and Guibourt.*	*Duncan.*	*Bell and Co.*[3]
				(Avoidupois Weights.)	
Mercury.........	℥j.	32 parts.	30 parts.	℥iv.	℥viij.
Nitric Acid......	fʒxj. (sp. gr. 1·5).	48 parts (sp. gr. 1·286).	60 parts (sp. gr. 1·321).	℥xij. (Nitrous Acid sp. gr. 1·380 to 1·390) ℥xv.	f℥xiv. (sp. gr. 1·43).
Lard	℥iij.	250 parts.	240 parts.		lb. iij.
Olive Oil	0	250 parts.	240 parts.	℥xxxii.	lb. ij.
Neat's-foot Oil .	f℥ix.	0	0	0	0

The two most important points to attend to in the manufacture of this ointment are—the due regulation of the heat, and the employment of a proper quantity of acid.

"If the mixture be made at a low temperature, no effervescence takes place, and the ointment so produced will become hard in a few days, of a greenish-white colour, and eventually of a consistence that may almost be powdered; but if the oil or fat is heated to a sufficient temperature, or the quantity operated on is large enough to generate the heat required, strong effervescence takes place, much gas is evolved, and a perfect article is produced, of a fine golden colour, and the consistence of butter" (Alsop). The greater success which attends the manufacture of large than of small quantities of this ointment, may be referred to the higher temperature generated by the reaction of larger quantities of the materials. Mr. Alsop says that the proper temperature is between 180° and 212°. A temperature of 190° F. yielded a fine product.

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[1] Christison's *Dispensatory*. Mr. Duncan's process was communicated to the late Dr. Duncan (*Supplement to the Edinburgh Dispensatory*, p. 196, 1829).

[2] *Pharmacopée Raisonnée*, p. 448, 3me édit.

[3] Alsop, *Pharmaceutical Transactions*, No. iii. p. 162, 1841.

The importance of a sufficient quantity of acid has been already pointed out.

In the process of the London College, by which, when it is strictly followed, a very fine product is obtained, acid of a sp. gr. of 1·5 is directed to be used. But the sp. gr. of commercial nitric acid rarely exceeds 1·38 or 1·4. Hence, therefore, a larger quantity of commercial acid is required to be equivalent to the quantity of strong acid ordered by the Pharmacopœia. Mr. Schacht has shown that ointment spoiled by age or accident, and which has become hard, discoloured, pulverulent, or even blackened, may be restored to its original beauty by heating it with nitric acid; and he has further shown that the use of an excess of nitric acid in the manufacture of the ointment is no disadvantage, for, if the heat be continued long enough, it distils off. Stirring assists the evolution of gas, and is usually believed to favour the formation of a fine product; but Mr. Alsop asserts that a long-continued stirring is not required.

When fresh prepared, this ointment has a fine golden yellow colour, a butyraceous consistence, and a peculiar nitrous odour. It is very apt to become grey when mixed with other ointments, in consequence of their deoxidizing powers; and to prevent this, an additional quantity of nitric acid should be added. It should be spread with wooden or ivory spatulas.

When fresh prepared this compound contains the following substances, besides the ordinary constituents of lard and olive oil:—elaïdine; red oil, elaidate of mercury (mercurial soap), and nitrate of mercury.

Elaïdine is a white saponifiable fat, fusible at 97° F. [89·6 F. according to Meyer],[1] very soluble in ether, but requiring 200 times its weight of boiling alcohol to dissolve it. It consists of elaïdic acid and glycerin.

It is an irritant and slight caustic. When it has undergone decomposition by keeping, it irritates ulcers exceedingly, and even excites slight erysipelatous inflammation.

We employ it as a stimulant and alterative in *chronic diseases of the skin,* more particularly those affecting the hairy scalp, as the different forms of porrigo, in which it is exceedingly efficacious. It is also used as a *dressing to ulcers*—to stimulate and cleanse them—as in foul syphilitic sores and phagedenic ulcers. Lastly, it is employed in *ophthalmic diseases*—more particularly ophthalmia tarsi, or psorophthalmia, in which it is applied (mixed with its own weight of almond oil) by means of a camel's-hair pencil to the lids, frequently with such advantage that some have regarded it as a specific in this complaint.

173. HYDRARGYRI ACETAS.—ACETATE OF MERCURY.

Formula $Hg^2O,\bar{A}$. *Equivalent Weight* 259.

HISTORY.—This compound was known to Lefebure in the 17th century.

PREPARATION.—In the *Dublin Pharmacopœia* the directions for procuring it are the following:—

Take of Purified Mercury, Acetate of Potash, of each, nine parts; Diluted Nitric Acid, eleven parts; Boiling Distilled Water, one hundred parts; Distilled Vinegar, as much as may be sufficient.

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[1] *Pharmaceutisches Central-Blatt für* 1840, S. 790.

Let the Nitric Acid be added to the Mercury, and when the effervescence has ceased, let the mixture be digested that the metal may be dissolved: let the Acetate of Potash be dissolved in water, and let the distilled vinegar be added until the acid shall predominate in the liquor; to this, whilst boiling, let the solution of the Mercury in the Nitric Acid be added, and let the mixture be filtered as quickly as possible through a double linen cloth: let it cool that crystals may form: having washed these with cold distilled water, dry them on paper with a very gentle heat. In every step of this process let glass vessels be employed.

By the mutual action of diluted nitric aid and mercury we obtain a protonitrate of mercury (see *ante*, p. 873). When this is mixed with acetate of potash, double decomposition takes place: nitrate of potash and protoacetate of mercury being formed ($Hg^2O,NO^5+KO,\bar{A}=Hg^2O,\bar{A}+KO,NO^5$). To prevent precipitation of the yellow subnitrate of mercury, excess of acetic acid should be employed; and by filtering, whilst hot, any subnitrate which may be formed would be separated before the acetate has deposited.

Properties.—This salt occurs in white, micaceous, flexible scales, which are inodorous, but have an acrid taste. It blackens by light. When heated it is resolved into carbonic acid, acetic acid, and mercury. It is very slightly soluble, in water, requires 300 times its own weight of this liquid to dissolve it, according to Dumas. It is insoluble in cold alcohol: boiling alcohol abstracts part of its acid.

Characteristics.—Its appearance, its slight solubility in water, and the action of heat on it, are some of its characteristics. Heated with sulphuric acids the vapour of acetic acid is evolved. The fixed alkalies precipitate the black oxide of mercury. Chloride of sodium forms calomel with it.

Composition.—It has the following composition:—

	Atoms.	*Eq. Wt.*	*Per Cent.*	*Dumas.*
Suboxide of Mercury	1	208	80·3	80·66
Acetic Acid	1	51	19·7	19·34
Acetate of Mercury	1	259	100·0	100·00

Physiological Effects.—It is one of the milder mercurial preparations. From the reports of Guarin, Colombier, and Vogler,[1] it appears to have acted in some cases with great violence, and to have occasioned violent vomiting, purging, abdominal pain, bloody evacuations, &c. These effects probably arose from the presence of some acetate of the binoxide of mercury.

Uses.—It was introduced into practice in consequence of being supposed to be the active ingredient of Keyser's anti-venereal pills. But Robiquet has subsequently ascertained that Keyser employed the acetate of the binoxide.[2] It is occasionally used in syphilitic affections.

Administration.—The dose of it is from one to five grains. A solution composed of one grain of the acetate dissolved in an ounce of water, may be used as a *wash*. An *ointment* is prepared by dissolving two or three scruples in an ounce of olive oil.

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[1] Wibmer, *Wirkung d. Arzneim.* iii. 647.

[2] Dumas, *Traité de Chimie*, v. 178.

ORDER XXX. SILVER AND ITS COMPOUNDS.

174. ARGENTUM.—SILVER.

Symbol Ag. *Equivalent Weight* 108.

HISTORY.—Silver, like gold, has been known from the most remote periods of antiquity, being mentioned in the earliest books of the Old Testament.[1] It was termed by the alchemists and astrologers *Diana* or *Luna* ☽.

NATURAL HISTORY.—It is found in the mineral kingdom in various states; sometimes nearly pure, or alloyed with other metals (especially gold, antimony, tellurium, arsenicum, and copper); or combined with sulphur, selenium, iodine, bromine, or chlorine. Of these, *native silver* and the sulphuret are by far the most abundant. A native carbonate of silver is described, but is exceedingly rare.

It is totally dissolved by diluted nitric acid. This solution, on the addition of chloride of sodium, throws down a precipitate, which an excess of ammonia dissolves, and it should be free from colour. The chloride of silver being removed, and hydrosulphuric acid added to the solution, it is not coloured by it, and nothing is thrown down. The specific gravity of silver is 10·4.—*Ph. L.*

Soluble entirely in diluted nitric acid: this solution, treated with an excess of muriate of soda, gives a white precipitate entirely soluble in aqua ammoniæ, and a fluid which is not affected by sulphuretted hydrogen.—*Ph. Ed.*

Physiological Effects.—Silver in the metallic state is totally inert. It may remain for many months in the alimentary canal without exciting any ill effects.[1] Colic, however, has been ascribed to the handling of it.[2]

Uses.—In pharmacy it is used for the preparation of the nitrate, which is employed as a medicine and as a test.

Silver leaf is used for filling the hollows of decayed teeth, and is sometimes employed to cover pills. An *amalgam of silver* is also used by some dentists for stopping teeth. It is objectionable on account of its becoming black by the formation of sulphuret of silver.

as dep
ceous, fl
kens by

175. Argenti Oxydum—Oxd mercurSilver.

eight of
Formula AgO. *Equivalent* cold alco

History.—The compound was a constituent o *icum lunare* of Angelus
Sala,[3] and which was lauded in diseases of the brght solubility Van Mons[4] and Serre[5]
used it in syphilis. More recently it has been ageristics. Hc notice by Dr. Butler
Lane.[6] It is sometimes called *protoxide of s* The fixed alk*toxydum*), or *argentum
oxydatum fuscum.*

Preparation.—This compound is obtained ium forms calom r or liquor potassæ to
a solution of nitrate of silver. One equivaleromposition :— nitrate of silver require
one equivalent or 47 parts of anhydrous po *Wt.* *Per Cent.* f the pure hydrate of
potassa) to decompose them. AgO,NO^5+K 08 .... 80·3 Dr. Butler Lane[7] re-
commends four parts of nitrate of silver a 51 .... 19·7 drate of potash, to be
separately dissolved in distilled water, and th ——— of potash being filtered
to separate the oxide of iron and other impuri 59 .... 100·0 impurity of the hydrate
of potash of the shops, and the solvent act the tissue of the filter,
are objections to this mode of proceeding. potassæ appears to me
to be preferable, as the precipitant of the ne of the milder me added until it ceases to
throw down any more oxide from the solutr, and Vogler,[1] it silver. The precipitated
oxide is to be carefully and repeatedly wad to have occasionter, then collected on a
filter, and dried at a temperature of abovacuations, &c.

Ammonia must not be substituted fo cetate of the binoxi account both of the facility
with which an excess of it dissolves t danger of the formation of
fulminating silver. Several severe a practice in conse have attended its manufacture by
means of ammonia, and Dr. Butler eyser's anti-ven when the oxide thus prepared is
made up into pills, spontaneous co eyser employ o ensue.

Oxide of silver may be prepared ic affection e moist and recently prepared chloride
of silver with a very strong solution it potash.[8]

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[1] *Lond. Med. Gaz.* May 20, 1837.

[2] *Journal de Chimie Médicale*, t. vi. 2me séries, 1840.

[3] Gmelin, *App. Medicaminum*, vol. i. p. 362, 1795.

[4] Riecke, *Die neuern Arzneimittel.* 2te Aufl. 1840.

[5] *Mém. sur l'emploi des préparations d'argent dans le traitement des maladies vénériennes*, 1836.

[6] *Medico-Chirurgical Review*, July 1840; *Lancet*, July 10th, 1841; *Lond. Med. Gaz.* April 10 and May 1, 1846.

[7] *Pharmaceutical Journal*, vol. vi. p. 170, 1846.

[8] Gregory, *Pharmaceutical Journal*, vol. ii. p. 724, 1843.

PROPERTIES.—Oxide of silver is a dark olive brown powder, tasteless or nearly so. By a dull red heat or by long exposure to light it is decomposed into oxygen gas and metallic silver. It is insoluble in the fixed alkalies, readily soluble in caustic ammonia, and very slightly soluble in water; the aqueous solution has an alkaline reaction and a metallic taste, and is rendered turbid by a small quantity of carbonic acid, but is dissolved by an excess of it.

COMPOSITION.—Oxide of silver has the following composition:

	Atoms.	*Eq. Wt.*	*Per Cent.*	*Berzelius.*	*Davy*
Silver	1	108	93·103	93·103	93·1
Oxygen	1	8	6·897	6·897	6·9
Protoxide of Silver	1	116	100·000	100·000	100·0

PHYSIOLOGICAL EFFECTS.—Its local effects are very slight, and are those of a very mild astringent and slight caustic. It does not possess the powerful chemical action of the nitrate of silver on the animal tissues. When swallowed it forms in the alimentary canal a combination, which, being soluble, is absorbed. After its absorption, it produces remote or constitutional effects analogous to, but milder than, those of the nitrate. It has been described as possessing sedative ("organic sedative") and indirect tonic properties. Occasionally it has excited salivation. Like the nitrate, and probably all other preparations of silver, its continued use is apt to be followed by discolouration of the skin.[1] But, probably because it less readily forms a soluble combination in the alimentary canal, it is somewhat less apt to discolour the skin; and, for the like reason, is less powerful in its action on the system, and less influential in the treatment of diseases than the nitrate of silver.

USES.—Its uses are analogous to those of the nitrate. It is well adapted for painful (neuralgic) and irritable conditions of the stomach and intestines, especially those which are attended with augmented secretions. Thus in gastrodynia and enterodynia, in pyrosis and chronic diarrhœa, it has proved serviceable. In uterine diseases, especially where there are augmented discharges and great irritability, it has been found beneficial, as in hysteralgia, menorrhagia, leucorrhœa, and dysmenorrhœa. It has also been used in epilepsy and syphilis. Externally it has been employed in the form both of powder and ointment; in irritable ulcers, both syphilitic and non-syphilitic, in ophthalmia, in sore nipples, and in gonorrhœa. In the latter complaint it was used in the form of ointment applied to the urethral membrane by means of a bougie.

ADMINISTRATION.—The dose of it is from gr. ss. to gr. ij. twice or thrice daily, in the form of powder or pill. It may be continued for five or six weeks with safety; but its prolonged employment is liable to be attended with permanent discolouration of the skin. For external use it may be applied in the form of ointment composed of ʒj. of oxide to ℥j. of lard.

176. Argenti Chloridum.—Chloride of Silver.

Formula $AgCl$. *Equivalent Weight* 143·5.

Muriate of Silver (*Argenti Murias*); *Horn Silver* (*Luna Cornea*).—This compound is found native. It may be obtained by adding an excess either of hydrochloric acid, or a solution of common salt to a solution of nitrate of silver. $AgO,NO^5 + HCl = HgCl + HO,NO^5$. The white precipitate should be washed, collected on a filter, and dried at a gentle heat in the dark. (The chemical properties of chloride of silver have been before alluded to, see *ante*, p. 369). It was formerly used in medicine by Poterius, Tackenius, and Fred. Hoffman,[2] but fell into disuse. More recently its medicinal employment has been recommended by Dr. Perry,[3] an American physician, in epilepsy, chronic dysentery, and chronic diarrhœa.—Dose, three grains four or five times daily. Thirty grains at one dose caused vomiting. Twelve grains administered daily for three months produced no unpleasant symptoms.

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[1] Dr. B. Lane, *Lond. Med. Gaz.* April 10, 1846; Dr. Christison, *Dispensatory*, 2d edit.

[2] *Operum Supplementum*, Pharm. Spagyr. cap. xv. p. 270, ed. 2nda. 1754.

[3] Dunglison, *New Remedies*.

177. ARGENTI NITRAS.—NITRATE OF SILVER.

Formula AgO,NO^5. *Equivalent Weight* 170.

HISTORY.—Geber[1] describes the method of preparing crystallized nitrate of silver. When this salt is fused, it is termed *lunar caustic* (*causticum lunare*). The term *infernal stone* (*lapis infernalis*) is sometimes applied to this salt, as well as to the hydrate of potash. Nitrate of silver is sometimes called *argentum nitratum*.

PREPARATION.—All the British Colleges give directions for the preparation of this salt.

The *London College* orders of Silver, ℥iss.; Nitric Acid, f℥j.; Distilled Water, f℥ij. Mix the nitric acid with the water, and dissolve the silver in them in a sand-bath. Afterwards increase the heat gradually, that the nitrate of silver may be dried. Melt this in a crucible, with a slow fire, until, the water being expelled, ebullition has ceased; then immediately pour it into proper moulds.

The directions of the *Edinburgh College* are essentially similar, except that the salt is ordered to be fused in an earthenware or porcelain crucible, and the fused matter poured into iron moulds previously heated and greased slightly with tallow. Preserve the product in glass vessels.

The *Dublin College* directs two forms of nitrate of silver to be prepared; the one in crystals (*argenti nitratis crystalli*), the other fused (*argenti nitras fusum*). The *crystallised* nitrate is prepared of silver laminated and cut into small fragments, *thirty-seven* parts; Diluted Nitric Acid, *sixty parts*. Let the silver be passed into a glass vessel, and let the acid, previously diluted with water, be poured on it. Dissolve the metal with a heat gradually increased; then, by evaporation and refrigeration, let crystals be formed, to be dried without heat, and to be preserved in a glass vessel placed in darkness.

The following are directions for preparing the *fused* nitrate:—Let silver be dissolved in Diluted Nitric Acid as above described; then let the liquor be evaporated to dryness. Let the remaining mass, passed into a crucible, be liquified by a slow heat. Let them be poured into proper moulds, and preserved in a glass vessel.

The fusion may be more readily and safely effected in a Berlin porcelain capsule over a spirit or gas lamp, by means of Griffin's lamp furnace, than in a crucible over a slow fire, as directed in the London Pharmacopœia. Care must be taken not to overheat, and thereby to decompose the salt. The moulds should be warmed. It is unnecessary and objectionable to grease the moulds, as directed by the Edinburgh College.

Three equivalents of silver abstract three equivalents of oxygen from one equivalent of nitric acid, thereby disengaging one equivalent of binoxide of nitrogen, and forming three equivalents of oxide of silver, which unite with three equivalents of nitric acid to form three equivalents of nitrate of silver. $3Ag+4NO^5=3(AgO,NO^5)+NO^2$.

MATERIALS.			PRODUCTS.
1 eq. Nitric Acid 54	*1 eq. Binox. Nitrogen* 30		1 eq. Binox. Nitrogen . 30
	3 eq. Oxygen 24	3 eq. Ox. Silver 348	
3 eq. Silver 324			
3 eq. Nitric Acid 162			3 eq. Nitrate Silver 510
540			540

PROPERTIES.—Nitrate of silver forms transparent, colourless, right rhomboic prismatic crystals (*argenti nitratis crystalli*). Its taste is strongly

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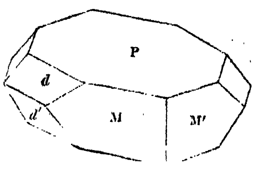
[1] *Invention of Verity*, ch. xxi.

FIG. 145.



Crystal of Nitrate of Silver.

metallic and bitter. When heated, it fuses into a grey mass: if the temperature be increased, decomposition ensues, and metallic silver is obtained. The fused nitrate forms, on cooling, a whitish, striated mass, having a crystalline texture. When cast into small cylinders, it forms the *lunar caustic* of the shops, and which is the *argenti nitras* of the London Pharmacopœia; the *argenti nitras fusum* of the Dublin Pharmacopœia. The paper in which the cylinders are usually rolled decomposes, blackens, and ultimately reduces the nitrate to the metallic state. The salt is soluble in both water and spirit. It does not deliquesce: when exposed to the atmosphere and solar light, it blackens, probably from the action of organic matter, or hydrosulphuric acid, contained in the atmosphere. Mr. Scanlan[1] finds that nitrate of silver in a clean dry glass tube, hermetically sealed, undergoes no change of colour by exposure to solar light: the contact of organic matter, however, readily occasions it to become black. A solution of nitrate in pure distilled water is unchanged by exposure to solar light; but the presence of organic matter causes the liquid to become black or reddish. (See *ante*, pp. 280 and 289.)

Characteristics.—It is known to be a *nitrate* by its deflagration when heated on charcoal, and the evolution of nitrous fumes, as well as by the other characters before mentioned for this class of salts (see *ante*, p. 412). Its characters as a *salt of silver* are as follows:—It yields with hydrochloric acid a white precipitate (AgCl), whose properties have been before stated (see *ante*, p. 369). It forms, also, with solutions of the alkaline carbonates, oxalates, and ferrocyanides, white precipitates (*carbonate, oxalate, and ferrocyanide of silver*). With a solution of phosphate of soda it yields a yellow precipitate ($3AgO,cPO^5$); with the alkaline arsenites, a yellow precipitate ($2AgO,AsO^3$); with arsenic acid, a brick-red precipitate ($3AgO,AsO^5$); and with lime water or the fixed alkalies, olive brown (AgO). Phosphorus and metallic copper each precipitate crystals of metallic silver from the aqueous solution of this salt. Hydrosulphuric acid occasions a black precipitate (AgS).

COMPOSITION.—Nitrate of silver is thus composed:—

	Atoms.	*Eq. Wt.*	*Per Cent.*	*Proust.*
Oxide of Silver	1	116	68·23	69·5
Nitric Acid	1	54	31·76	30·5
Nitrate of Silver	1	170	99·99	100·0

PURITY.—Nitrate of silver should be white, and completely soluble in distilled water. By the action of organic matters and light it blackens, from a partial reduction. The presence of copper may be detected in its solution by the blue colour produced with caustic ammonia. The watery solution from which the silver has been thrown down by the hydrochloric acid, should be unchanged by the addition of hydrosulphuric acid, showing the absence of lead and copper, and be completely volatilized by heat: if any saline residuum be obtained, the nitrate was adulterated. A chemical manufacturer informs me that he has detected 10 per cent. of nitrate of potash in the nitrate of silver of commerce. It was recognised by precipitating the silver by means of hydrochloric acid, and subsequently crystallizing the nitrate of potash. "Pure fused nitrate of silver, ignited by the blowpipe in a small cavity of a piece of dense charcoal, leaves about 63 per cent. of pure silver" (Brande). The white precipitate produced with either hydrochloric acid or chloride of sodium should be readily dissolved by caustic ammonia: if chloride of lead be present the effect will be otherwise.

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[1] *Athenæum*, August 25, 1838.

It is originally white, but blackens by exposure to light. It is entirely soluble in water. Copper put into the solution precipitates silver; its other properties are as above detailed respecting silver.—*Ph. Lond.*

Soluble in distilled water, with the exception of a very scanty black powder: twenty-nine grains dissolved in one fluidounce of distilled water, acidulated with nitric acid, precipitated with a solution of nine grains of muriate of ammonia, briskly agitated for a few seconds, and then allowed to rest a little, will yield a clear supernatant fluid, which still precipitates with more of the test.—*Ph. Ed.*

PHYSIOLOGICAL EFFECTS. *a. On Animals.*—Orfila[1] found that it acted on animals as a powerfully corrosive poison. When dogs were made to swallow it, gastro-enteritis was induced. No symptoms indicating its absorption were observed. Dissolved in water, and thrown into the jugular vein, it produced difficult respiration, convulsive movements, and speedy death.

β. On Man.—The *local action* of nitrate of silver is that of a caustic or corrosive. This might be expected, from observing its action on albumen and fibrin, substances which form the principal part of the animal textures. If a solution of nitrate of silver be added to an albuminous liquid, a white curdy precipitate is formed, composed[2] of *albumen* 84·5, and *nitrate of silver* 15·5. This precipitate is soluble in caustic ammonia, and in solutions of nitrate of silver, albumen, and chloride of sodium. After some time it becomes coloured, and ultimately blackish, from the partial or complete reduction of the silver. The action of nitrate of silver on milk,[3] as well as on fibrin, is analogous to that on albumen; that is, a white compound of nitrate of silver and of these organic substances is at first formed, but gradually the metal is reduced. These facts assist us in comprehending the nature of the changes produced by the application of nitrate of silver to the different tissues.[4]

Applied to the skin it produces first a white mark, owing to its union with the coagulated albumen of the cuticle: gradually this becomes bluish-grey, purple, and ultimately black, owing to the partial reduction of the silver. If the integument be moistened, and the nitrate applied three or four times, it causes at the end of some hours vesication, which is usually attended with less pain than that produced by cantharides. In some cases it excites acute pain. In one instance in which I applied it freely to the scalp for a cutaneous affection, fever with delirium was produced, which endangered the life of the patient (a girl of six years). This is deserving of notice, because in Mr. Higginbottom's work[5] we are told that nitrate of silver applied as a vesicant "causes scarcely any constitutional irritation, even in children."

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[1] *Toxicol. Gén.*

[2] Lassaigne, *Journ. de Chim. Méd.* t. vi. 2e série, p. 306.

[3] Dr. C. G. Mitscherlich, *Pharmaceutisches Central-Blatt für* 1839, S. 447.

[4] See some remarks of Mulder on the action of metallic salts on fibrin and albumen, in the *Pharmaceutisches Central-Blatt für* 1838, S. 515.

[5] *Essay on the Use of the Nitrate of Silver*, 2d edit. p. 198.

In a few days the black and destroyed cuticle cracks and falls off, without any destruction of the subjacent cutis vera.

Applied to the hair or nails, the nitrate stains them black, as in the case of the cuticle; and, in consequence, it is one of the substances employed as a *hair dye* (see *ante*, p. 156). When recently applied, the black tint of the hair, and even of the cuticle, may be removed by washing with a solution of chloride of sodium, and then with ammonia-water, to dissolve the chloride of silver which is produced.[1] To detect silver in stained hair, the latter is to be treated with chlorine or iodine, by which chloride or iodide of silver is produced, which is soluble in ammonia and in hyposulphite of soda. It is precipitable from its solution in ammonia by nitric acid.[2] Part of the black colour of the hair stained by the nitrate depends on the formation of sulphuret of silver.

When nitrate of silver is applied to an ulcer, it produces a white film (owing to its union with the albumen, and perhaps, also, with the chloride of the secretion). This film in a few hours assumes a dark colour, and ultimately forms a black eschar. This hardens, and in a few days becomes corrugated, separates at the edges, and at length peels off altogether, leaving the surface of the sore beneath in a healed state.[3] The intensity of the pain varies much in different cases; but it is, on the whole, very much less than might be imagined by those who have not tried this remedy.

When applied to mucous membranes, a similar white compound of the nitrate with the animal matter of the secreted mucus is formed, and this defends the living tissue from the action of the caustic, so that the effects are not so violent as might be expected. Thus the solid nitrate may be applied to the mucous surface of the vagina, and even to the os uteri, in cases of leucorrhœa and gonorrhœa, oftentimes without exciting any pain or inflammation: in some instances, however, it produces smarting pain, which lasts for several hours, but no serious effects have resulted from its use, even when, by accident, two drachms of nitrate have been left to dissolve in the vagina.[4]

Its chemical effects on the other mucous membranes are analogous to those just mentioned, but the pain which it produces varies with different membranes, and in the same membrane under different states. Its application to the conjunctiva is attended with acute pain (especially when inflammation is going on), though in general this soon subsides. On all these surfaces it acts as an astringent.

The safety with which, in most cases, large doses of the nitrate are administered internally, must depend on the presence of the mucus which lines the internal coat of the stomach, and on chlorides and free hydrochloric acid contained in this viscus. These form with the nitrate new compounds (*albuminate* and *chloride*), less energetic in their local action than the nitrate. It is deserving of especial notice that larger doses may be exhibited, without inconveniencing the stomach, in the form of pill than in that of solution; in consequence, I presume, of the latter acting on a larger surface.

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[1] *Journ. de Chim. Méd.* vii. 542.

[2] Devergie, *Méd. Lég.* ii. 933; Herapath, *Pharm. Journ.* vol. vi. p. 476.

[3] Higginbottom, *op. cit.* p. 10.

[4] Dr. Hannay, *Lond. Med. Gaz.* xx. 185; also Mr. Bell, *ibid.* 473; and Dr. Jewell, *Pract. Observ. on Leucorrhœa.*

[5] *Med. Trans. of the College of Physicians*, iv. 85.

Dr. Powell[5] in some cases was enabled to give fifteen grains at a dose in the form of pills, while he rarely found stomachs that could bear more than five grains in solution. Fouquier[1] has also remarked the greater activity of the solution. If cautiously exhibited, beginning with small doses and gradually increasing them, it may be exhibited for a considerable period without producing any obvious changes in the corporeal functions, though it may be exercising a beneficial influence over the constitution, evinced by its amelioration of certain diseases, as epilepsy. In some cases it has caused an eruption.[2] If the dose be too large, it occasions gastrodynia, sometimes nausea and vomiting, and occasionally purging. Taken in an excessive dose, it acts as a corrosive poison, but cases of this kind are very rarely met with. Boerhaave mentions an instance in which it caused excruciating pain, gangrene, and sphacelus of the first passages.

All the above-mentioned effects are referable to its local action, and from them we have no evidence of its absorption, or of the nature of its influence over the general system. But the discoloration of the skin, presently to be noticed, fully proves that absorption does take place when the medicine is exhibited in small but long-continued doses. It exercises a specific influence over the nervous system; at least I infer this, partly from the effects observed by Orfila when it was injected into the veins of animals, and partly from its occasional curative powers in affections of this system; as epilepsy and chorea.

The blueness, or slate colour, or bronze hue of the skin just alluded to, has been produced in several patients who have continued the use of the nitrate during some months or years.[3] In some of the cases the patients have been cured of the epilepsy for which they took the medicine; in others the remedy has failed.[4] In one instance which fell under my notice, the patient, a highly respectable gentleman residing in London, was obliged to give up business in consequence of the discoloration; for when he went into the street, the boys gathered around him, crying out "There goes the blue man." In this instance no perceptible diminution of the colour had occurred for several years; but in some cases it fades in intensity. The corion is the essential seat of it. Dr. Baddeley[5] found that blisters rose white,—a proof that in his patient the colouring matter was below the epidermis. But in some instances the cuticle and corpus mucosum of the face and hands participate in the tint. In one instance the mucous membrane of the stomach and intestines was similarly tinted. A case is mentioned by Wedemeyer[6] of an epileptic who was cured by nitrate of silver, but eventually died of diseased liver and dropsy: all the internal viscera were more or less blue, and Brande, a German chemist, obtained metallic silver from the plexus choroides and pancreas. The discoloration of the skin is usually regarded as permanent and incurable; but I have been informed that in one instance washes of dilute nitric acid diminished it. If this observation be correct, I would suggest the exhibition of nitric acid internally, as well as its external use. Dr. A. T. Thomson[7] suggests that, if nitric acid were conjoined with nitrate of silver, the discoloration might be prevented. But if the acid were efficacious, his hypothesis, that the colour depends on blackened chloride of silver, will be disproved; for nitric acid can neither prevent the action of the compounds of chlorine on the salts of silver, nor can it dissolve the white chloride or the black subchloride.

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[1] *Dict. Mat. Med.* i. 403.

[2] Sementini, *Quart. Journ. of Science*, xii. 189; Copland, *Dict. Pract. Med.* i. 68.

[3] *Med.-Chir. Trans.* vii. and ix.

[4] Rayer, *Treatise on Skin Diseases*, by Willis, 961.

[5] *Med.-Chir. Trans.* ix. 238.

[6] *Lond. Med. Gaz.* iii. 650.

[7] *Elements of Mat. Med.* i. 715.

USES.—Nitrate of silver has been employed *internally* in a very few cases only; and of these the principal and most important are epilepsy, chorea, and angina pectoris. Its liability to discolour the skin is a great drawback to its use; indeed, I conceive that a medical man is not justified in risking the production of this effect without previously informing his patient of the possible result. Dr. Osborne[1] ascribes its good effects to its allaying irritation of the gastric membrane. But in a larger number of instances the asserted existence of this irritation is a mere assumption, perfectly devoid of proof.

In *epilepsy* it has occasionally, perhaps more frequently than any other remedy, proved successful. Drs. Sims,[2] Baillie, R. Harrison, Roget, and J. Johnson,[3] have all borne testimony to its beneficial effects. Its *methodus medendi* is imperfectly understood. This, indeed, is to be expected, when it is considered that the pathology and causes of epilepsy are so little known; and that, as Dr. Sims has justly observed, every thing concerning this disease is involved in the greatest doubt and obscurity, if we except the descriptions of a single fit, and that it returns at uncertain intervals. In this state of ignorance, and with the already-mentioned facts before us, as to the curative powers of this salt, the observation of Georget,[4] that he has great difficulty in conceiving how the blindest empiricism should have led any one to attempt the cure of a diseased brain by cauterizing the stomach, is, I conceive, most absurd and unwarranted. The cases which have been relieved by it are probably those termed by Dr. M. Hall[5] eccentric. In the few instances in which I have seen this remedy tried, it has proved unsuccessful; but it was not continued long, on account of the apprehended discoloration of the skin.

In *chorea* it has been successfully employed by Dr. Powell,[6] Dr. Uwins,[7] Dr. Crampton,[8] Lombard,[9] and others. In *angina pectoris* it has been administered in the intervals of the paroxysms with occasional success by Dr. Cappe[10] and Dr. Copland.[11]

In *chronic affections of the stomach* (especially morbid sensibility of the gastric and intestinal nerves) it has been favourably spoken of by Autenreith,[12] Dr. James Johnson,[13] and Rueff.[14] It has been employed to allay chronic vomiting connected with disordered innervation, as well as with disease of the stomach (scirrhus and cancer), and to relieve gastrodynia. The foregoing are the most important of the diseases against which nitrate of silver has been administered internally.

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[1] *Dublin Med. Journ.* Jan. 1839.

[2] *Mem. of the Med. Soc. of Lond.* iv. 379.

[3] *Treat. on Nerv. Dis.* by J. Cooke, M.D. ii. part 2, 147.

[4] *Physiol. du Système Nerv.* ii. 401.

[5] *Lect. on the Nerv. System*, p. 143.

[6] *Medical Transactions of the College of Physicians*, iv. 85.

[7] *Edinb. Med. and Surg. Journ.* viii. 407.

[8] *Transactions of the King and Queen's College of Physicians*, iv. 114.

[9] *Rust's Magazine*, xl.

[10] *Duncan's Annals of Medicine*, iii.

[11] *Op. cit.*

[12] Dierbach's *Neust. Entdeck. in d. Mat. Med.* 1837, i. 528.

[13] *On Indigestion*, 2d edit. p. 87.

[14] Dierbach, *op. cit.*; also *American Journal of Medical Science*, May 1837, p. 225.

As an *external agent* its uses are far more valuable, while they are free from the inconvenience of permanently staining the skin. It is employed sometimes as a *caustic*, and as such it has some advantages over potassa fusa and the liquid corrosives. Thus, it does not liquefy by its application, and hence its action is confined to the parts with which it is placed in contact. It is used to remove and repress spongy granulations in wounds and ulcers, and to destroy warts, whether venereal or otherwise. It is applied to chancres on their first appearance, with the view of decomposing the syphilitic poison, and thereby of stopping its absorption, and preventing bubo or secondary symptoms. This practice has the sanction of Mr. Hunter. I have several times seen it fail, perhaps because it was not adopted sufficiently early. The nitrate should be scraped to a point, and applied to every part of the ulcer. This mode of treating chancres has been recently brought forward by Ratier[1] as if it were new, and as forming part of Bretonneau's *ectrotic* (*ectrotica*, from ἐκτιτρώσκω, *I abort*) method of treating diseases!

The application of nitrate of silver to *punctured wounds* is often attended with most beneficial effects, as Mr. Higginbottom[2] has fully proved. It prevents or subdues inflammatory action in a very surprising manner. It is equally adapted for poisoned as for simple wounds. To promote the healing of *ulcers* it is a most valuable remedy. In large indolent ulcers, particularly those of a fistulous or callous kind, it acts as a most efficient stimulant. To small ulcers it may be applied so as to cause an eschar, and when at length this peels off, the sore is found to be healed. Mr. Higginbottom[3] asserts that "in every instance in which the eschar remains adherent from the first application, the wound or ulcer over which it is formed invariably heals." Dry lint will, in general, be found the best dressing for sores touched with the nitrate.

Nitrate of silver was proposed by Mr. Higginbottom as a topical remedy for external inflammation. It may be applied with great advantage to subdue the inflammatory action of erythema, of paronychia or whitlow, and of inflamed absorbents. In some cases it is merely necessary to blacken the cuticle; in others, Mr. Higginbottom recommends it to be used so as to induce vesication. In erysipelas, nitrate of silver is used by many surgeons as a cautery both to the inflamed and the surrounding healthy parts. But I have so often seen the disease continue its course as if nothing had been done, that I have lost confidence in its efficacy.[4] I have found tincture of iodine much preferable.

Bretonneau and Serres[5] recommend the *cauterization of variolous pustules* by nitrate of silver, in order to cut short their progress. It is principally useful as a means of preventing pitting, and should be employed on the first or second day of the eruption. The solid caustic is to be applied to each pustule after the apices have been removed. This ectrotic method has also been employed in the treatment of *shingles* (herpes zoster): in one case the disease was cured in a few hours.[1] Some good rules for its application have been laid down by Rayer.[2]

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[1] *Arch. Gén. de Méd.* xv. 47; and xvi. 62.

[2] *Op. cit.*

[3] *Op. cit.* p. 11.

[4] See also some remarks by Velpeau, in *Lond. Med. Gaz.* Aug. 21 1840, p. 828.

[5] *Arch. Gén. de Méd.* viii. 220 and 427.

In some diseases of the eye nitrate of silver is a most valuable remedial agent. It is used in the solid state in solution and in ointment: the solution may be used as a wash or injection, or applied by a camel's hair pencil. In deep ulcers of the cornea, a cone of the solid nitrate should be applied,—in superficial ones, a solution (of from four to ten grains of the salt to an ounce of distilled water) may be employed.[3] There is one drawback to the use of this substance in ulcers of the cornea, as well as other affections of the eye: viz. the danger of producing dark specks in the cornea, or of staining the conjunctiva;[4] but this occurrence is rare. Velpeau[5] has employed it in many hundred cases without ever observing such an effect. In both acute and chronic ophthalmia, Mr. Guthrie[6] employs this salt in the form of ointment (Arg. Nitr. gr. ij. ad gr. x.; Liq. Plumbi Subacet. gtt. xv.; Ung. Cetacei, ʒj.) Of this, he directs a portion (varying in size from a large pin's head to that of a garden pea) to be introduced between the lids by the finger or a camel's hair pencil. It causes more or less pain, which sometimes lasts only half an hour, at others till next day. Warm anodyne fomentations are to be used, and the application of the ointment repeated every third day. In acute cases, two or three applications will arrest the disease. With this treatment, blood-letting, and the use of calomel and opium, are preceded or conjoined.[7] While many surgeons hesitate to use nitrate of silver in the first stage of acute purulent ophthalmia, all are agreed as to its value in the second stage of the disease, as well as in chronic ophthalmia. Besides the diseases of the eye already mentioned, there are many others in which the oculist finds this salt of the greatest service, as a caustic, astringent, or stimulant.[8]

In *inflammatory affections and ulcerations of the mucous membrane of the mouth and fauces*, nitrate of silver is sometimes a most valuable application.[9] When the fibrinous exudation of croup commences on the surface of the tonsils and arches of the palate, its further progress may be stopped, according to Mr. Mackenzie,[10] by the application of a solution composed of a scruple of nitrate of silver and an ounce of distilled water. The solid nitrate has been introduced through an aperture in the trachea, and applied to ulcers on the inner surface of the larynx, in a case of phthisis laryngea, with apparent benefit.[11]

In some forms of *leucorrhœa* the application of nitrate of silver, either in the solid state or in solution, is attended with beneficial effects. This practice was first recommended by Dr. Jewel.[12] It is, I believe, most successful in cases dependent on local irritation or subacute inflammation, and not arising from constitutional debility. The solution may be applied by a piece of lint or sponge, or may be injected by means of a syringe with a curved pipe. Its strength must vary according to circumstances. Dr. Jewel generally employed three grains of the nitrate to an ounce of water; but in the Lock Hospital, solutions are sometimes used containing half a drachm, or even two scruples, to the ounce. In some cases the solid nitrate has been applied to the cervix uteri and vagina by means of a silver tube. In *gonorrhœa of the female*, a solution of the nitrate of silver, or even this caustic in the solid state, has been used with the best effects. It was first employed by Dr. Jewel, but subsequently, and on a much more extended scale, by Dr. Hannay,[1] and without any injurious consequences. In many cases the discharge ceased, never to return, in twenty-four hours. The fear of ill effects has prevented the general adoption of this practice. In *gonorrhœa of the male*, the introduction of a bougie, smeared with an ointment of nitrate of silver, is occasionally a most effectual cure; but the practice is dangerous. In one case I saw acute and nearly fatal urethritis brought on by its employment. The patient was a dresser at one of the London hospitals, and had practised this mode of treatment in many instances on the hospital patients with the happiest results. An aqueous solution of the salt has been successfully used in chronic gonorrhœa.[2]

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[1] *Archives Gén. de Méd.* xviii. 439.

[2] *Treatise on Skin Diseases*, by Willis, p. 260.

[3] Mackenzie, *On the Diseases of the Eye*, 2d ed. 578; also, Velpeau, *Lond. Med. Gaz.* Oct. 1839.

[4] Jacob, *Dublin Hospital Reports*, v. 365.

[5] *Op. supra cit.* p. 107.

[6] *Lond. Med. and Phys. Journ.* lx. 193; lxi. 1.

[7] For some judicious remarks on this practice, consult the article *Ophthalmia*, by Dr. Jacob, in the *Cyclop. of Pract. Med.* iii. 201.

[8] Vide Dr. Mackenzie's *Treatise on Diseases of the Eye;* and Mr. Ryall's paper, in the *Trans. of the King and Queen's College of Physicians in Ireland*, v. 1.

[9] Hunt, *Lond. Med. Gaz.* xiii. 129.

[10] *Edinb. Med. and Surg. Journ.* xxiii. 294.

[11] Liston, *Elements of Surgery*, part ii. p. 256.

[12] *Practical Observations on Leucorrhœa*, 1830.

In *fissured or excoriated nipples* the application of the solid nitrate of silver is of great service. It should be insinuated into all the chaps or cracks, and the nipple afterwards washed with tepid milk and water.[3]

The application of solid nitrate of silver is a most effectual remedy for the different forms of *porrigo* which affect the heads of children. The caustic should be well rubbed into the parts. I have never known the practice to fail, or to cause the loss of hair. Where the greater portion of the scalp is involved, the different spots should be cauterized successively at intervals of some days; for, as already mentioned, I have seen fever and delirium produced in a child from the too excessive use of this remedy. In *psoriasis*, the same medicine was found by Dr. Graves[4] most effectual. An aqueous solution of the nitrate is also valuable as an astringent wash in other skin diseases, as *impetigo*. The solid nitrate is sometimes employed to stop the progress of irritative or erysipelatous inflammation, by applying it in a circular form around, and at a little distance from, the inflamed portion; but I have frequently observed the inflammation extend beyond the cauterized part. Mr. Higginbottom[5] reports favourably of the effects of applying the nitrate to *burns* and *scalds;* and his observations have been confirmed by those of Mr. Cox.[6]

In strictures of the urethra and œsophagus, bougies armed with lunar caustic on their points (*the caustic* or *armed bougie*) are occasionally employed with great advantage, at least in urethral stricture. When the common bougie (*cereolus simplex*) is formed, the point of it should be heated with a conical piercer, and the caustic introduced while the composition is quite soft. The point of the bougie should then be rubbed quite smooth on a piece of polished marble till no inequality in the size of it appear.[1] Notwithstanding that the application of nitrate of silver to stricture of the urethra has been advocated by Mr. Hunter, Sir E. Home, Mr. Wilson, Dr. Andrews, and others, it is now but little employed; yet of its efficacy and safety in many obstinate cases, where the simple bougie fails, I am assured by repeated observation. It is commonly supposed that it acts by burning or destroying the stricture: such is not the fact. It induces some change in the vital actions of the part, which is followed by a relaxation of the narrowed portion of the canal, but which change is as difficult to explain as the subduction of the internal inflammatory action by the application of this salt. Of the use of the caustic bougie in stricture of the œsophagus I have no experience.

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[1] *Lond. Med. Gaz.* xx. 185.

[2] Rognetta, *Lancette Française*, Mars 31, 1836.

[3] *Lond. Med. Gaz.* v. 207; xiv. 674, 719, and 754.

[4] *Ibid.* vii. 520.

[5] *Op. cit.*

[6] *Lond. Med. Gaz.* x. 687.

ADMINISTRATION.—Nitrate of silver may be exhibited in doses of one-sixth of a grain, gradually increased to three or four grains, three times a day. As before mentioned, Dr. Powell has increased the dose to fifteen grains. The usual mode of administering it is in the form of pills made of bread-crumb; but the chloride of sodium which it contains renders it objectionable: some mild vegetable powder with mucilage is preferable. Common salt or salted foods should not be taken either immediately before or after swallowing these pills. Dr. Johnson[2] asserts "that there is no instance on record where the complexion has been affected by the medicine when restricted to three months' administration." It is advisable, however, not to continue the use of it beyond a month or six weeks at a time.

For external use, an aqueous solution is employed of strengths varying from a quarter of a grain to two scruples, in an ounce of distilled water. The formula for Mr. Guthrie's ointment has already been given.

ANTIDOTE.—The antidote for nitrate of silver is common salt (*chloride of sodium*), When this comes in contact with lunar caustic, nitrate of soda and chloride of silver are produced: the latter compound is, according to the experiments of Orfila,[3] innocuous. The contents of the stomach should be removed, and the inflammatory symptoms combated by demulcents, blood-letting, and the usual antiphlogistic means.

When the local use of nitrate of silver causes excessive pain, relief may be gained by washing the parts with a solution of common salt. Pieces of caustic have been left in the vagina and urethra without unpleasant consequences resulting. Injections of a solution of common salt are the best means of preventing bad effects.

To diminish the slate-coloured tint of the skin arising from nitrate of silver, acids or the super-salts offer the most probable means of success. The external and internal use of dilute nitric acid, or the internal employment of bitartrate of potash, may be tried: the discoloration is said to have yielded to a steady course of the last-mentioned substance.[4]

1. LIQUOR ARGENTI NITRATIS, L.; *Solutio Argenti Nitratis*, E.; *Solution of Nitrate of Silver.* (Nitrate of Silver, ʒj. [grs. 40, *E.*]; Distilled

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[1] Dr. Andrews, *Observations on the Application of Lunar Caustic to Strictures*, p. 126, 1807.
[2] *Essay on Morbid Sensibility of the Stomach and Bowels*, 2d edit. p. 90.
[3] *Toxicol. Gén.*
[4] *United States Dispensatory.*

Water, f℥j. [grs. 1600, *E.*] Dissolve the nitrate of silver in the water, and strain; then, the access of light being prevented, keep it in a well-closed vessel.)—This solution is employed as a test of chlorine, chlorides, or hydrochloric acid.

2. **SOLUTIO ARGENTI AMMONIATI, E.**; *Solution of Ammonio-Nitrate of Silver; Hume's Test for Arsenious Acid.* (Nitrate of Silver, grs. xliv.; Distilled Water, f℥j.; Aqua Ammoniæ, a sufficiency. Dissolve the salt in the water, and add the aqua ammoniæ gradually, and towards the end cautiously, till the precipitate at first thrown down is very nearly, but not entirely, redissolved.)—Employed as a very delicate test for arsenious acid (see *ante*, p. 645).

Order XXXI. GOLD AND ITS COMPOUNDS.

178. AURUM.—GOLD.

Symbol Au. *Equivalent Weight* 199.

History.—Gold has been known from the most remote periods of antiquity. It was in common use 3,300 years since,[1] and was probably the first metal with which mankind was acquainted. The alchemists termed it *Sol*, or *Rex metallorum*, ☉.

Natural History.—It is found only in the metallic state, commonly alloyed with other metals, especially with silver, tellurium, copper, and iron. It occurs in veins in primitive rocks, and is also found in alluvial deposits in small lumps or particles, called *gold dust*. It is found in several parts of Europe, Asia, and Africa, but principally in America, especially the southern part.

Preparation.—The mode of extracting gold varies in different places, principally according to the nature of the gangue. The ore is freed as much as possible from foreign matters by mechanical processes (stamping, washing, &c.), and sometimes by roasting, and is then smelted with some flux, as borax, to separate the stony matters. Or it is fused with lead, and afterwards submitted to cupellation; or amalgamated with mercury, and, after straining, distilled.

The separation of gold from silver (*parting*) may be effected in the *dry way* by fusion either with sulphur, by which metallic gold and sulphuret of silver are procured,—or with tersulphuret of antimony, by which sulphuret of silver and an alloy of gold and antimony are procured: the last-mentioned metal may be separated by heating the alloy in the air, as well as by other methods. Gold may also be freed from silver in the *wet way* by the process of *quartation*; that is, by treating an alloy of three parts of silver and one of gold with nitric acid, which dissolves the silver,—or by action of sulphuric acid (see *cupri sulphas*).

Properties.—The crystalline forms of native gold are the cube, the regular octohedron, and their modifications. Pure gold has a rich yellow colour,—a sp. gr. of 19·2 to 19·4; is soft, very ductile, and malleable; fuses at a bright red heat (2016° F., according to Daniell); and in the liquid state has a brilliant greenish colour.

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[1] *Exodus*, xi. 2.

Characteristics.—Gold is readily distinguished by its colour and softness, by its being unacted on by nitric acid, and by its ready solubility in nitro-hydrochloric acid. The solution is yellow, stains organic matters (as the skin) purple, throws down, by the addition of protosulphate of iron, metallic gold in a finely-divided state; by protochloride of tin, a dark or black precipitate; and by protonitrate of mercury, a black precipitate: heated with borax by the blowpipe, it forms a pink or rose-coloured glass, but is subsequently reduced.

PHYSIOLOGICAL EFFECTS.—Gold, like other metals, has been frequently supposed to be inert while it retains its metallic condition, but in this, as well as in some other instances, the accuracy of the assumption has been denied. Both Chrestien[1] and Niel,[2] as well as other writers, assert that finely-divided metallic gold (*pulvis auri*) produces the same constitutional effects as those caused by the various preparations of this metal, but in a milder degree, while it excites little or no irritation. It is said to promote the secretions of the skin, kidneys, and salivary glands.

USES.—It has been employed as an antivenereal and antiscrofulous remedy by Chrestien, Niel, and others, with considerable success. It is said to be preferable to the other preparations of this metal in delicate and nervous subjects, females, and infants. Gold leaf (*aurum foliatum* seu *lamellatum*) is used by dentists for filling decayed teeth, and was formerly employed by apothecaries for covering pills (*ad inaurandas* seu *obducendas pilulas*).

ADMINISTRATION.—It has been administered internally in doses of from a quarter of a grain to a grain three or four times a day. Chrestien used it by way of friction on the tongue and gums. Niel employed it endermically (that is, applied it to the skin deprived of the epidermis) in the form of ointment, composed of one grain of gold and thirty grains of lard.

PULVIS AURI (Fr. Cod.) or *Powder of Gold* is prepared by rubbing leaf gold (*aurum in laminas exilissimas complanatum*) with sulphate of potash, sifting, and washing with boiling water to remove the sulphate; or by adding protosulphate of iron to terchloride of gold, and by washing the precipitate first with water, then with dilute nitic acid.

179. AURI TEROXYDUM.—TEROXIDE OF GOLD.

Formula AuO^3. *Equivalent Weight* 223.

This substance, sometimes called *peroxide of gold*, *auric oxide*, or *auric acid*, is ordered, in the French Codex, to be prepared by boiling 4 parts of calcined magnesia with 1 part terchloride of gold and 40 parts of water. Then wash, first with water, to r nove the chloride of magnesium, afterwards with dilute nitric acid, to diss od. the excess of magnesia.

Teroxide of gold is browr he state of hydrate, reddish-yellow. It is reduced by heat and solar light. It is insoluble in water, but is soluble in hydrochloric acid (forming terchloride of gold) and in alkalies (forming aurates).

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[1] *Sur une Nouvelle Remi* éd. xxxvii. ar *itement des Mal. Vén.* Paris, 1811.

[2] *Recherches et Observ* *mploi dans le T* *ts des Préparations d'Or*, Paris, 1821.

xviii. 55.

xx. 414.

It is used internally, in venereal and scrofulous diseases, in doses of from one-tenth of a grain to a grain, made into the form of pills, with extract of mezereon.

1. **AURUM FULMINANS**; *Fulminating Gold; Aurate of Ammonia; Ammoniuret of Teroxide of Gold.*—This is prepared by adding ammonia to a solution of chloride of gold. It is a yellowish-brown powder, which explodes when heated to 400°. Its composition is probably $2NH^3,AuO^3$. It has been employed in the same cases as the preceding compounds, as well as in fevers, nervous affections, &c. In some cases it has produced very serious, and even fatal results.[1]

2. **PURPURA MINERALIS CASSII**; *Purple of Cassius; Aurum Stanno paratum*, Fr. Cod.—There are several methods of preparing it: the simplest is to add a solution of the mixed protochloride and perchloride of tin to a solution of terchloride of gold until a precipitate is no longer produced. Filter and dry the precipitate.

The purple of Cassius is soluble in ammonia, and does not form an amalgam with mercury: hence it does not appear to contain any metallic gold. Its composition probably varies according to the mode of procuring it. Gold, oxygen, and tin, are its essential constituents. According to Fuchs, its composition is $2(SnO,SnO^2)+AuO^2,SnO^2+Aq$.

This preparation is used in the same cases as the other preparations of gold.

180. AURI TERCHLORIDUM.—TERCHLORIDE OF GOLD.

Formula $AuCl^3$. *Equivalent Weight* 305·5.

PREPARATION.—In the French Codex this is ordered to be prepared by dissolving, with the aid of heat, one part of gold in three parts of nitro-hydrochloric acid. The solution is to be evaporated until vapours of chlorine begin to be disengaged, and then allowed to crystallize.

PROPERTIES.—Terchloride of gold is in the form of small crystalline needles, of an orange-red colour, inodorous, and having a strong, styptic, disagreeable taste. It is deliquescent, on which account it should be preserved in a well-stoppered bottle: it is soluble in water, alcohol, and ether. When heated, it evolves chlorine, and is converted, first into protochloride, and then into metallic gold, which is left in the spongy state. It reddens litmus, stains the cuticle purple, is reduced by many metals (as iron, copper, tin, zinc, &c.), by several of the non-metallic elementary substances (as phosphorus), by some metallic salts (as protosulphate of iron), and by many organic bodies (as charcoal, sugar, gum, gallic acid, extractive[illegible].), all of which, therefore, are incompatible with it. Nitrate of silver o[illegible]s a precipitate of chloride of silver and oxide of gold: hydrochloric ac[illegible]ative goes the latter.

PHYSIOLOGICAL EFFECTS. *a. On Animals.*—Orfila[1] examined the effects of chloride of gold on animals, and infers from his experiments that when introduced into the stomach it acts as a corrosive (but with less energy than the bichloride of mercury), and destroys animals by the inflammation of the coats of the alimentary canal which it sets up.

β. On Man.—On man its effects are analogous to those of bichloride of mercury. In *small doses* it acts, according to Dr. Chrestien, more energetically as a stimulant, though less powerfully as a sialogogue, than corrosive sublimate. It promotes the secretions of the skin, the salivary glands, and the kidneys. Taken to the extent of one-tenth of a grain daily, it has occasioned violent fever. "This excitation," says Chrestien, "I regard as indispensably necessary for the cure of the diseases against which I administer gold: restrained within proper limits it is never accompanied with any remarkable or even sensible lesion of the functions. The mouth is good, the tongue moist, the appetite continues, the bowels are not disordered, and there is ordinarily only augmentation of urine and transpiration; but if carried too far, we incur the risk of producing general erethism, inflammation of this or that organ, according to the predisposition of the patient, which will not only check the treatment, but may even induce a new disease, often more troublesome than the original one. The suspension or modification of the remedy should be governed by the unusual and sustained heat of the skin." Cullerier,[2] the nephew, has seen one-fifteenth of a grain excite, at the second dose, gastric irritation, dryness of the tongue, redness of the throat, colic, and diarrhœa. When it promotes the secretion of saliva, it does not, as mercury, affect the teeth and gums.[3] Magendie[4] has seen violent gastritis, accompanied by nervous symptoms (cramps and pains in the limbs, agitation, and loss of sleep), and afterwards great heat of skin, obstinate sleeplessness, and fatiguing erections. In *large doses*, it would probably occasion symptoms analogous to those produced by the use of poisonous doses of bichloride of mercury.

USES.—It has been employed, with variable success, as a substitute for mercury in the secondary symptoms of syphilis. A more extended experience of it is, however, necessary to enable us to speak of its remedial powers with confidence. In the hands of Chrestien,[5] Niel,[6] Cullerier,[7] Legrand,[8] and others, it has proved most successful.

It has also been used in scrofulous affections, bronchocele, chronic skin diseases, scirrhous tumors, &c. Duportal[9] cured with it a case of obstinate ulceration of the face, regarded by him as cancerous, and which had resisted all the ordinary methods of cure.

Legrand[10] has used chloride of gold, acidified with nitric acid, as a caustic, in syphilitic, scrofulous, and scorbutic ulcers, cancerous growths, and ulcerations of the neck of the uterus.

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[1] *Toxicol. Gén.*

[2] Magendie, *Formulaire*, 8me édit. p. 305.

[3] Grötzner, *Rust's Magazin*, Bd. xxi. quoted by Wibmer.

[4] *Op. cit.*

[5] *Op. cit.*

[6] *Op. cit.*

[7] *Dict. des Sciences Méd.* xxxvii. art. *Or.*

[8] *De l'Or; de son Emploi dans le Traitement de la Syphilis*, Paris, 1832.

[9] *Ann. de Chimie*, lxxviii. 55.

[10] *Lond. Med. Gaz.* xx. 414.

ADMINISTRATION.—Internally, it has been given in doses of one-twentieth of a grain, made into pills with starch. But as organic matters decompose it, it is better to use it in distilled water, or apply it by friction to the mouth, in quantities of from one-sixteenth to one-sixth of a grain.

ANTIDOTE.—The same as for poisoning by perchloride of mercury.

181. AURI IODIDUM.—IODIDE OF GOLD.

Formula AuI. *Equivalent Weight* 325.

This is ordered to be prepared, in the French Codex, by adding a solution of iodide of potassium to a solution of chloride of gold. Double decomposition takes place, and iodide of gold falls down. $AuCl^3+3KI=AuI+3KCl+2I$. This is to be collected on a filter, and washed with alcohol, to remove the excess of iodine which precipitates with it.

Iodide of gold is of a greenish-yellow colour, insoluble in cold water, but slightly soluble in boiling water. Heated in a crucible it evolves iodine vapour, and is converted into metallic gold.

It has been employed internally, in venereal affections, in doses of from one-fifteenth to one-tenth of a grain. Externally, it has been applied in the form of ointment to venereal ulcers.[1]

182. SODII AURO-TERCHLORIDUM.—AURO-TERCHLORIDE OF SODIUM.

Formula $NaCl,AuCl^3,4HO$. *Equivalent Weight* 400.

In the French Codex this is ordered to be prepared by dissolving 85 parts by weight of terchloride of gold, and 16 parts of chloride of sodium, in a small quantity of distilled water: the solution is to be evaporated by a gentle heat until a pellicle forms, and then put aside to crystallize.

The auro-terchloride of sodium crystallizes in orange-coloured quadrangular, elongated prisms, which are permanent in the air; but when they contain any uncombined terchloride of gold, they are slightly deliquescent. They are soluble in water. When heated, chlorine is evolved, and a mixture of gold and chloride of sodium is left behind.

Its effects and uses are analogous to the terchloride of gold, over which it has the advantages of being more constant and less costly. It is exhibited internally in doses of one-twentieth to one-tenth of a grain, made into pills with starch or lycopodium. Mixed with twice its weight of orris powder or lycopodium, it may be used in frictions on the tongue and gum. An ointment (composed of one grain to thirty-six grains of lard) may be applied endermically to the skin, deprived of its epidermis by a blister.

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[1] Pierquin, *Journ. de Progrès.*

ORDER XXXII. COMPOUNDS OF PLATINUM.

183. Platini Bichloridum.—Bichloride of Platinum.

Formula $PtCl^2$. *Equivalent Weight* 170.

Perchloride of Platinum; Muriate of Platinum; Nitromuriate of Platinum.—Obtained by dissolving platinum in nitrohydrochloric acid: by evaporation, prismatic crystals of the hydrated bichloride of platinum ($PtCl^2,10HO$) are obtained. On further evaporation, a dark reddish-brown, deliquescent, saline mass of anhydrous bichloride of platinum ($PtCl^2$) is obtained. It is soluble in water, alcohol, and ether. Its effects on the animal body have been investigated by C. G. Gmelin,[1] Höfer,[2] and others. It is a powerful caustic poison. Given to rabbits in doses of about thirty grains, it causes convulsions and death. Considered in relation to its therapeutical effects and uses, it resembles terchloride of gold and perchloride of mercury. It has been successfully employed in secondary syphilis. Dose from one-eighth to one quarter of a grain taken several times daily. It may be administered either in solution in water, and mixed with mucilage, or in the form of pills. An ointment composed of fifteen grains of the bichloride, half a drachm of extract of belladonna, and an ounce of lard, has been applied to indolent ulcers.

184. Sodii Platino-Bichloridum.—Platino-Bichloride of Sodium.

Formula $NaCl,PtCl^2$. *Equivalent Weight* 228·5.

Sodio-bichloride of Platinum; Chloro-platinate of Sodium; Platinum Muriaticum Natronatum.—Obtained by dissolving 170 parts of pure bichloride of platinum and 58·5 of pure chloride of sodium in separate portions of distilled water. The solutions are to be mixed and evaporated so as to obtain red crystals, $NaCl,PtCl^2,6HO$. By heat these lose their water of crystallization, and yield the anhydrous platino-bichloride of sodium, $NaCl,PtCl^2$, in the form of a yellow powder. This salt is soluble in both water and alcohol. Its general effects are similar to, but milder than, those of the bichloride of platinum; and for medicinal use it is preferable to the latter preparation. It resembles in its medicinal uses the auro-terchloride of sodium. It has been used in secondary syphilis, and some other maladies. The dose of it is from one-eighth to half of a grain, administered in the form of powder, pill, or aqueous solution containing mucilage. A solution composed of ʒss. dissolved in half a pint of decoction of poppies has been used as an injection in gonorrhœa. A liniment composed of two grains of the salt to an ounce of oil or fat has also been used.[3]

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[1] *Versuche über die Wirkungen des Barytes,* &c., *Platins,* &c. Tubingen, 1824.

[2] *Observations et Recherches expérimentales sur la Platine,* Paris, 1841; also *Journ. de Pharm.* t. xxvii. 1841.

[3] For further details respecting the medicinal uses of the compounds of platinum, the reader is referred to Dierbach's *Neuesten Entdeckungen in der Materia Medica,* Bd. ii. S. 1173, 1843.

END OF VOL. I.

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